WATERBIRD AND SHOREBIRD USE OF BEACHES IN BRUNSWICK COUNTY, NORTH CAROLINA

December 2000 - November 2001

Prepared for:

U. S. ARMY CORPS OF ENGINEERS
WILMINGTON DISTRICT
Wilmington, North Carolina

Contract No DACW 54-97-D-0028
Delivery Order 24

MAY 2002

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1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Wilmington District (Corps), has implemented a Wilmington Harbor deepening project that will involve the disposal of up to 5.6 million cubic yards of sandy dredged material on the beaches of Bald Head Island, Caswell Beach, Oak Island, and Holden Beach in Brunswick County, North Carolina. This disposal will occur over a distance of about 14 miles, during 2001 and 2002. Shorebirds and colonial waterbirds often use beach habitats for nesting, foraging, resting, and roosting. The purpose of this study is to monitor bird use of these beach habitats and collect data to assess the impacts of beach renourishment on these birds. This report summarizes information from surveys between 15 December 2000 and 30 November 2001.

1.1 Background Information. In recent years there has been increasing concern on the effects of habitat alteration and disturbance on selected waterbird groups. One of the most important factors to colonial nesting waterbirds is the availability of suitable, undisturbed nesting habitat. Many colonial nesting waterbirds (primarily pelicans, gulls, terns, and black-skimmer) in North Carolina that once were dependent on nesting sites in association with ephemeral beach and inlet habitats are now dependent on selected dredged-material sites (Parnell and Soots 1975, Parnell and Shields 1990). The concentration of more birds nesting at fewer sites has increased the risk of catastrophic nesting failures. Human activities and predatory species present an increasing source of disturbance for nesting, feeding, and resting birds in all coastal habitats.

Shorebirds (primarily sandpipers, plovers, willet, turnstones, and oyster catchers) represent another group of waterbirds that has been the subject of recent concern and studies. Some shorebird species spend up to two-thirds of the year in migration and on wintering grounds (Burger 1984). Most shorebirds migrate between the Arctic tundra breeding grounds and South American wintering grounds. Recent studies have documented the importance of staging areas for these long-distance migrants (Myers et al. 1987, Clark et al. 1993, Hicklin 1987, Dodd and Spinks 2001). Many shorebirds take advantage of seasonally abundant food resources at these intermediate staging areas along their annual migratory cycle.

There is relatively little information on the effects of beach renourishment on bird populations. There has been one study in the general vicinity of the study area that includes a characterization of beach use by birds in three 1.5 km transects in New Hanover County (Smith 1988). Information on seasonal numbers and distribution of

shorebirds on North Carolina's Outer Banks is available from over 123 km surveyed in 1992 and 1993 (Dinsmore et al. 1998). Abundance information is available on shorebird populations in Virginia (Watts and Truitt 2000) and South Carolina (Dodd and Spinks 2001). Most studies have concentrated on seasonal abundance, habitat use and identifying important staging areas. No detailed, comprehensive studies or data are available for bird use of beaches in Brunswick County, North Carolina.

2.0 STUDY AREA

Eleven transects were surveyed under the USACE Delivery Order for this portion of the study. Three transects were located on Bald Head Island, four on Oak Island, and four on Holden Beach. Two additional transects were surveyed with the same protocol at Ocean Isle Beach under a separate USACE Delivery Order. Detailed results and information from these two transects are found in a separate report, but some data from these sites are discussed herein in comparison to data from this study.

Transects covered all habitats from the primary dune to the intertidal/surf habitat. Transects were established to represent all habitat types in the study area and varied in length because an effort was made to cover all potentially suitable nesting habitats, especially in the vicinity of inlets. Transect lengths ranged from 1.6 km (1 mile) to 3.2 km (1.75 miles). The cumulative length of these eleven transects was 20 km (13.25 miles). Transects were referenced with sequential numbers (i.e., transects 1 through 11) from east to west (Figures 1 through 4). A summary of transect locations, features, and characteristics is found in Table 1. Coordinates along each transect were determined using a sub-meter accuracy global positioning system (GPS) and are referenced with visual features in Appendix A.

3.0 METHODS

3.1 Survey Seasons and Zones. Transects were identified as those subject to year-round surveys or those subject to non-breeding season surveys (Table 1). Five transects (1, 3, 7, 8, and 11) were surveyed year-round, because they contain potential nesting habitat. Six transects (2, 4, 5, 6, 9, and 10) were surveyed during the non-breeding season. All transects were surveyed with the same frequency during the non-breeding season. Six additional surveys were conducted during the breeding season for the five year-round transects.

Surveys during the non-breeding season were conducted at different frequencies, based on known seasonal abundances of waterbirds and shorebirds in the region. Surveys were conducted weekly during migration (15 July to 30 November

and 15 February to 30 May) and every other week during the mid-winter period (1 December to 15 February). Weekly surveys for breeding birds were conducted from 1 March through 15 July for the year-round transects. Since the breeding survey period overlaps the migration periods, surveys for both breeding and non-breeding use were combined for these periods of overlapping coverage.

Each transect was divided into three zones of microhabitat (intertidal/surf, beach, and dune areas), and four equally spaced zones along the longitudinal axis of the transects, represented as East, East-middle, West-middle, and West on the data sheet. Bird species and numbers were recorded in these zones along with the bird's activity (i.e., feeding, resting, flying, or breeding). Beach was defined as the area from the normal high water/tide (often denoted with the presence of a berm) to the toe of the primary dune. Overwash areas were included within the beach microhabitat. Any disturbances (e.g., people, pets, dredging, and predators) were also recorded.

3.2 Survey procedures. The duration of each survey varied among transects and within transects depending on the amount and type of habitat covered, and the number of birds present. All habitats including dunes, beach, and intertidal zones were surveyed in each transect. This was accomplished by walking parallel to the beach in most areas, but also required walking paths that zig-zagged across wider habitats. Transects were surveyed slowly and thoroughly to allow detection of all individuals of all species present and to insure that large mixed flocks of birds were thoroughly searched to locate, identify, and count all individuals of all species. Because all individuals were counted, the level of effort per km surveyed was considered equal for all transects.

Surveys were conducted during daylight hours between 30 minutes after sunrise to 30 minutes before sunset. Surveys were not conducted during poor weather conditions (heavy wind $>$ 25 mph, heavy rains, severe cold). Weather conditions including clouds, wind speed, wind direction, air temperature, and water temperature were recorded for each survey. Wind speed and air temperature were calculated using a Brunton Windwatch and wind direction was determined using a compass. Surf water temperatures were obtained from the *Wilmington Morning Star* newspaper. Tide times were recorded for each survey and were obtained from NOAA, National Service tide tables and corrected to the closest location where tidal correction times were provided. Each survey was categorized into one of two tidal categories (low or high) based on the time of the survey and the time to the closest low or high tide. Therefore, those surveys within $3\pm$ hours of high tide were classified as occurring at high tide. If a survey period included time from both categories, the survey was recorded in the category where more time was spent. This information along with the date, times of surveys, and location of each observation was recorded on a daily field data sheet.

Additional data on nesting species were recorded during the breeding season. These data included nesting chronology (e.g. dates when birds were first seen on the site, nest establishment dates, dates when unfledged chicks are present on the site), locations of the nests using GPS technology, locations of brood foraging territories for shorebirds, and known or suspected causes of nest and chick loss (e.g., pets, predators, and humans). Particular attention was concentrated in the vicinity of inlets, which typically provide the best nesting habitat for shorebirds and colonial waterbirds. Potentially nesting plovers were watched with care, and suitable nesting habitat for plovers was thoroughly searched for any isolated nests. All sightings of piping plovers were reported to the USACE, U.S. Fish and Wildlife Service (USFWS), and N.C. Wildlife Resources Commission (NCWRC).

3.3 Statistical Analysis. The possible effects of renourishment could differ for shorebird and waterbird species, therefore individuals were classified as waterbirds or shorebirds and analyzed separately. The data were further divided into beach and inlet transects due to potential differences in habitat use between shorebirds and waterbirds.

Monthly differences in abundance (number of individuals) and species richness (number of species) were examined using monthly means from unnourished transects 1, 4, 8, 9, 10, and 11. Monthly comparisons were also made, with beach and inlet transects analyzed separately. All comparisons used a one factor repeated measures analysis of variance (ANOVA) on monthly transect means. If a significant month effect was found ($\propto = .05$), a Student-Newman-Keuls multiple comparison procedure was performed to determine which months were significantly different.

Also of interest was the effect of tide on abundance and richness. To test whether tide was a significant factor in either parameter, mean high tide and low tide abundance and richness were calculated for each of the unnourished transects, 1, 4, 7, 8, 9, 10, and 11. The means were then analyzed for significant differences using a t-test, or, when appropriate, a Wilcoxon Rank Sum test.

Total abundance and species richness were the parameters used to examine the effects of beach replenishment. Sand was applied to the transects at different times of the year resulting in different pre- and post-nourishment dates for each transect. This necessitated that each renourished transect be compared to control transects separately. In order to ensure spatially independent sampling, control transects were located as far as possible from the renourished transect of interest.

When possible, the data were analyzed as a Before-After/Control-Impact design (BACI) (Stewart-Oaten and Murdock 1986, Schroeter et al., 1993). Control and renourished transects were monitored during the pre- and post-nourishment period

(henceforth designated as Before and After, respectively). For each sampling date, the difference between the renourished and control areas for the parameter of interest (Δ) was calculated. The control value was always subtracted from the renourished transect value, therefore, a negative Δ indicates that, for that sampling date, the value was higher at the control site. The mean Δs of the Before (Δ_b) and After (Δ_a) periods were then compared using a t-test. This method controls for seasonal variability and takes into account pre-existing differences in control and renourished areas, therefore, any significant differences between Δ_b and Δ_a can presumably be attributed to renourishment activity. Pre- and post-nourishment surveys were compared for species richness and abundance for waterbirds and shorebirds. Renourished beach transects (2 and 5) were compared with unrenourished/control beaches (9 and 10) using t-tests. A renourished inlet transect (3) was compared with unrenourished /control inlets (7, 8, and 11). For each transect, the respective control transects were averaged and this average was used to calculate Δ for that sampling date.

The statistical methods used here required that certain assumptions be met. First, the Δs from the before period must be additive. This means that, 1) Δ had no relationship to sampling week , and 2) Δ did not vary with the parameter of interest (e.g. Δ_b does not increase with abundance). Second, Δ_b and Δ_a are normally distributed and have equal variance. The additivity assumptions were checked by linear regression ($\alpha = .05$). The normality and equal variance assumptions were checked using the Kolmogorov-Smirnov test and Levene median test, respectively. If the pre-nourishment data failed the additivity tests, no statistical analysis was performed. If the normality or equal variance assumptions were not met, the data were log transformed or a non-parametric Wilcoxon rank sum test was used.

All comparisons were attempted using a 2 factor repeated measures analysis of variance (ANOVA) with area (control and renourished transect) as the main factor. For the ANOVA analysis, the multiple control areas were not averaged for each sampling date, but rather each was considered a separate experimental unit under the Control group. Failure to meet required assumptions resulted in use of t-test or, when appropriate, a Wilcoxon Rank Sum test.

Finally, the power of each test was calculated. Power refers to the probability that a statistical test will detect a treatment effect if an effect is actually present. The ability of the statistical test to detect treatment effects increases as power moves toward one. Power generally increases with sample size.

4.0 RESULTS AND DISCUSSION

4.1 Waterbird Species Richness. A summary of survey dates and corresponding survey week for all transects is found in Appendix B. Completed data sheets from each survey are found in Appendix C. Forty waterbird species were recorded from transects during the survey period (Table 2). Cumulative waterbird species richness was highest (31) on Transect 11 (Holden Beach, Shallotte Inlet) and lowest (14) on Transect 6 (Oak Island, West Beach). Cumulative species richness for waterbirds was highest (26) in November and lowest (12) in January (Figure 5). The total numbers of waterbird species recorded per survey by transect are found in Appendix D.

Monthly waterbird species richness (presented as species/km) for all unnourished transects (Cape, Transect 1; inlet: Transects 4, 8, 7, 11, and beach: Transects 9 and 10) can be found in Figure 6. Using these beach, inlet, and cape transects together, mean monthly waterbird species richness was lowest during December, January, and February and was highest in spring and fall. Statistically, richness in April was significantly higher than richness in January, February, and March. A significant month effect was found for inlet transect comparisons ($p = .005$) but not for beach transects ($p = .108$). Richness at inlets was significantly higher in April compared to January and February.

4.2 Waterbird Abundance. Waterbirds were most abundant at Transect 1 (Bald Head, Cape Fear) and Transect 5 (Oak Island, East Beach) with 138.8 birds/km and 138.4 birds/km, respectively. Waterbirds were least abundant at Transect 11 (Holden Beach, Shallotte Inlet) with 63.8 birds/km. The most abundant waterbirds (birds/km/survey) are found in Table 3 in each cape, beach, and inlet categories. Numbers of waterbirds peaked for the year during fall migration in November. The peak numbers of birds were recorded during September through November. Peak numbers during the fall migration were nearly twice the peak number recorded during spring migration in April (Figure 5). Waterbird numbers were lowest in December and January. The total numbers of individuals recorded per survey by transect are found in Appendix E.

Using all unnourished beach, inlet and cape transects together, mean monthly waterbird abundance (birds/km) was highest in September, October, and November and lowest in March and February (Figure 7). Statistically significant differences were found between September and February, September and March, and November and February. Inlet abundance was highest in September, October, and November and lowest in May. No significant difference between months was found ($p = .224$) for inlet abundance. For beach transects, abundance was greatest during spring and fall, and lowest during the early part of the year. However, no significant difference between months was found ($p = .07$).

The five most abundant waterbird species recorded were the Laughing Gull (*Larus atricilla*), Ring-billed Gull (*Larus delawarensis*), Brown Pelican (*Pelecanus occidentalis*), Royal Tern (*Sterna maxima*), and the Herring Gull (*Larus argentatus*) (Table 4). Although all of these species are present in the study area in some numbers throughout the year, the Ring-billed Gull and Herring Gull are more common winter residents and the Laughing Gull is a much more common summer resident.

4.3 Shorebird Species Richness. Twenty-four shorebird species were recorded from the transects during the survey period (Table 5). Cumulative shorebird species richness was highest (19), like waterbirds, on Transect 11 (Holden Beach, Shallotte Inlet) and lowest (7) on Transect 2 (Bald Head, South Beach). Cumulative species richness for shorebirds was highest in August (19) and May (17). Cumulative species richness for shorebirds was lowest (9) in January (Figure 8). The total numbers of shorebird species recorded by transect are found in Appendix F.

For all unnourished transects combined, mean monthly species richness was highest in May and in the fall months (Figure 9). Significant differences in richness were found for November and February, December, January, June, April and March. May had significantly higher species richness than February, December, June, April and March. Considering inlets alone, May was significantly higher than June and February, the two months with the lowest mean richness. Richness at beach transects was lowest in January and March and highest in May and the fall months. However, a significant difference between months was not found ($p = 0.062$).

4.4 Shorebird Abundance. Shorebirds were most abundant at Transect 4 (Oak Island, Caswell) with 33.8 birds/km and least abundant at Transect 2 (Bald Head, South Beach) with 5.3 birds/km. The most abundant shorebirds (birds/km/survey) are found in Table 6 for each cape, beach, and inlet categories. Numbers of shorebirds peaked during spring migration in May and during the fall migration, September through November (Figure 8). Shorebird numbers were lowest in June and December. The total numbers of individuals recorded per survey by transect are found in Appendix G.

Using all unnourished transects, mean monthly abundance (presented as birds/km) for shorebirds can be found in Figure 10. Total abundance was greatest in April, May, and November, though no month was statistically different from another ($p = .057$). Mean abundance was greatest at inlet sites during April, May, and November and lowest in February, June, and July. However, no significant differences in monthly means were detected for inlet transects ($p = .215$). Abundance at beach sites was generally highest in August, September, and October and lowest in December and March, but no significant month effect was found ($p = .335$).

The five most abundant shorebird species recorded were the Sanderling (*Calidris alba*), Willet (*Catoptrophorus semipalmatus*), Dunlin (*Calidris alpina*), Short-billed Dowitcher (*Limnodromus griseus*), and Black-bellied Plover (*Plavialis squatarola*) (Table 7). Only one of the five most abundant shorebird species, the Willet, is a breeder in North Carolina. All remaining four species breed in tundra habitat in the far north and occur in North Carolina as migrants or winter residents.

4.5 Habitat Use. More waterbirds and shorebirds were recorded in the intertidal/surf zone compared to beach and dune habitats. Habitat use by waterbirds in each of the three zones, with corresponding percent of total recorded, was intertidal/surf with 74 percent, beach with 17 percent, and dune with 9 percent. Habitat use by shorebirds in each of the three zones, with corresponding percent of total recorded, was intertidal/surf with 84 percent, beach with 14 percent, and dune with 2 percent.

When considering the geographic position of the transects and evaluating habitat use in the categories of beach, inlet, and cape, waterbird activity was highest in the intertidal zone of all three categories. Nearly 80 percent of all waterbird observations at both the cape and inlet transects were recorded in the intertidal zone (Table 8). Nearly 90 percent of all shorebird observations at both the cape and beach transects were recorded in the intertidal zone (Table 9). The highest percentage of beach use for waterbirds was recorded in beach transects and for shorebirds was recorded at inlet transects. It should be noted that habitat preference cannot be inferred since habitat use was not compared to habitat availability.

4.6 Activity. Approximately 50 percent of all waterbird observations were associated with feeding birds, 40 percent with flying/migrating birds, 9 percent resting birds, and less than one percent with breeding activity (Table 10). Feeding activity for waterbirds was highest (60.7 percent) at the cape transect and lowest (38.8 percent) at beach transects. Resting activity was relatively low (less than 14 percent) for waterbirds at all transects.

Approximately 60 percent of all shorebird observations were associated with resting birds, 25 percent with feeding birds, 14 percent with flying/migrating birds, and less than one percent with breeding activity (Table 11). Resting activity for shorebirds was highest (75.3 percent) at beach transects and lowest (40.1 percent) at inlet transects. Feeding activity for shorebirds was highest (48.4 percent) at inlet transects and lowest (12.1 percent) at the cape transect.

4.7 Nesting Birds. Signs of nesting were observed for Wilson's Plover (*Charadrius wilsonia*), Least Tern (*Sterna antillarum*), and Willet (*Catoptrophorus semipalmatus*) during the 2001 breeding season (Table 12). Two additional shorebird

species, American Oystercatcher (*Haematopus palliatus*) and Killdeer (*Charadrius vociferus*), probably nested in the vicinity. American Oystercatcher was documented nesting at Shallotte Inlet on Ocean Isle Beach. Wilson's Plovers were found nesting at all inlet transects and the transect at Cape Fear. Three pairs of Willets were found in the vicinity of Shallotte Inlet, two pair at Transect 11 and one pair on Ocean Isle.

Four of five Wilson's Plover nest attempts resulted in the production of at least six young. Only two Least Terns nests were found at one small colony site on Bald Head Island near the mouth of the Cape Fear River. Two young Least Terns were documented from one of these two nesting attempts. Although Willet were suspected of nesting in the soundside marsh, no nests, or young were found. Summary notes on nesting chronology on nesting and suspected nesting species are presented in Appendix H.

4.8 Observations of Disturbance. Fewest people per survey (7.9) were found on Transect 4, at Caswell, and the most were encountered at Transect 10, Holden Beach, West Beach (Table 13). Average number of people encountered per survey was 11.9 at the cape transect, 35.4 at inlet transects, and 42.6 at beach transects. Number of people encountered per survey by island averaged 11.4 at Bald Head Island, 36.4 on Oak Island, and 41.5 on Holden Beach. Most (84 percent) of the surveys recorded a disturbance from humans. Of these disturbances 22 percent contained a disturbance with a dog. No disturbance from predators was noted, although gulls and hawks, which often prey on other birds, young, or eggs, were documented. The presence of dog, raccoon (*Procyon lotor*) and people tracks were relatively common in the vicinity of all attempted nesting locations.

4.9 Effects of tide. Mean waterbird abundance and species richness are presented relative to low and high tide surveys for unnourished transects in Tables 14 and 15. Mean shorebird abundance and species richness are presented relative to low and high tide surveys for unnourished transects in Tables 16 and 17. Abundance of waterbirds was greater at high tide for all transects except Transect 9, and significant differences were found for Transects 1 ($p = 0.049$) and 4 ($p = 0.002$). Richness was generally similar at high and low tide, and no significant differences were found at any transect. Tide effects may differ between cape, inlet, and beach sites. Though only two beach transects were available for comparison, Table 14 suggests that tide may be less important in determining abundance at beach sites compared to inlet sites. For shorebirds, significant differences in abundance were present at all inlet transects. Shorebird richness was significantly different at all inlet transects except Transect 7. Specifically, shorebird abundance was greatest at high tide for Transects 4 ($p = < 0.001$), 7 ($p = 0.043$), 8 ($p = 0.002$), and 11 ($p = 0.018$). A significant tide effect was not present at the cape or beach sites.

4.10 Effects of Beach Renourishment on Waterbirds. Abundance (birds/km of transect) and richness (species/km of transect) for renourished transects and their respective controls are presented in Appendix I. The results of the t-test comparisons are shown in Tables 18 and 19. T-tests revealed no significant differences in the Δ_b and Δ_a for abundance at any renourished transect. At Transect 2, control abundance was generally greater during the Before and After period. Exceptions exist for the November surveys, but this occurred months after renourishment activity. Before period non-additivity was present at Transect 5 for survey weeks one to 33, requiring that only weeks 28 to 33 be used. For Transect 5, the Δ_a is much greater than Δ_b, indicating that, on average, Transect 2 has greater relative abundance in the after period. However, a week to week comparison of After period sampling dates indicates that abundance for Transect 5 actually has a variable relationship to control areas. Abundance at Transect 3 shows even greater variability both among sampling dates and in its relationship to the control areas, and again, no renourishment effects are evident. However, power was low for all three tests, so it is possible that effects existed, but simply were not detected.

The Δ_b and Δ_a for richness were found to be significantly different at Transect 3 ($p = .022$) only. Richness at Transect 2 was similar to control transects in both the Before and After period. Before period non-additivity was present at Transect 5 for survey weeks one to 33, requiring that only weeks 28 to 33 be used. Using this shorter Before period, no significant change in mean Δs was evident after nourishment. Richness was relatively lower at Transect 5 in both the Before and After periods. The Δ_b and Δ_a were significantly different for Transect 3. However, temporal changes in relative richness at the control and renourished sites began months after renourishment activity ended (Appendix I, I-5)

4.11 Effects of Beach Renourishment on Shorebirds. Abundance (birds/km of transect) and richness (species/km of transect) for renourished transects and their respective controls are presented in Appendix J. The results of the t-test comparisons are shown in Tables 20 and 21. Though no t-test was performed on Transect 2, differing relative abundances in the Before and After period can be seen in Appendix J (J-2). First, in the Before period the control abundance was either similar to Transect 2 or substantially higher at certain sampling dates. This lack of consistency in the relationship of the control areas and Transect 2 led to the violation of the additivity assumption. A different pattern is evident in the After period. Unlike the Before period, abundance is consistently lower than that of the control areas. However, it is difficult to attribute these results to a nourishment effect considering the non-additivity of the Before period and the lack of an apparent effect at the other transects. The Δ_b and Δ_a at Transect 5 was not significantly different, though Δ_b is higher than Δ_a. Monthly abundance patterns at Transect 3 suggest no nourishment effect. Except for occasional spikes in abundance at the control sites, control and nourished areas track well throughout the year.

Pre-nourishment richness was non-additive for Transect 2. However, post nourishment data do show consistently lower species richness at the renourished transect. Richness at Transect 5 varies greatly after nourishment, and though generally lower than control transects, the high variability make data interpretation difficult. Species richness at Transect 3 is generally similar to control areas both before and after nourishment, and no treatment effect is evident. However, the power of the tests was low, so it is possible that nourishment effects were missed.

4.12 Piping Plover Observations. Eighty Piping Plovers (*Charadrius melodus*) were noted during surveys from all Brunswick County transects. Over half (56 percent) of all Piping Plovers were recorded from Transect 4 (26 birds) and Transect 11 (19 birds) (Table 22). Six birds were recorded from Ocean Isle Beach. Piping Plovers were recorded from all but Transects 2, 6, and 9. Most birds were recorded at inlet transects (79 percent) or the cape transect (13 percent). Percentages of birds recorded in microhabitats were intertidal/surf at 56 percent, beach at 33 percent, and dunes at 11 percent. Percentages of birds in each activity category were feeding at 64 percent, flying at 21 percent, and resting at 15 percent. No nesting attempts were noted, nor were any birds present during the peak of the breeding season (10 May - 30 June).

5.0 SUMMARY

5.1 Species Richness and Abundance. A summary of species richness, abundance, habitat use and recorded activity by transect is found in Table 23 for waterbirds and Table 24 for shorebirds. Abundance and species richness for both shorebirds and waterbirds were generally greatest during fall and some of the spring months. The lowest abundance and richness numbers generally occurred in December, January, and February. A comparison of all transects showed the mean number of species encountered per survey was significantly higher for waterbirds ($p = <.001$) and shorebirds ($p = <.001$) at inlet transects compared to beach transects. Abundance (birds/km/survey) was higher for shorebirds at inlet transects compared to beach transects ($p = .032$). There was no significant difference for waterbird abundance between inlet and beach transects.

Compared to two other studies in North Carolina, the first-year data from Brunswick County are generally similar to a study conducted in New Hanover County in the mid 1980s (Smith 1988). The top five most abundant (percentage of the total individuals observed) species were the same for both waterbird and shorebird categories (Figures 11 and 12). Waterbirds comprised 83 percent of all waterbird and shorebird individuals, compared to 49 percent waterbirds and 51 percent shorebirds in New Hanover County, N.C. Species richness was slightly higher, but overall abundance

(peak and birds/km) was generally lower in this study. Mean number of shorebirds per km by transect ranged from 9.0 to 33.8 for this study. Mean number of shorebirds along the Outer Banks were 50 birds/km (range of 31 to 74) during the spring and 68 birds/km (range of 36 to 117) during the fall (Dinsmore et al. 1998).

5.2 Effects of Tide. Tide was a significant factor in abundance and species richness. At most transects, greater numbers of waterbirds were surveyed at high tide compared to low tide. Waterbird richness was also generally greater during high tide. Shorebirds exhibited a different pattern of behavior. Abundance and species richness were greatest during high tide at inlet transects only. At the beach and Cape sites, tide appeared to have no effect on shorebird richness or abundance.

5.3 Effects of Beach Renourishment. The Δ_b for waterbird abundance was greater than Δ_a at only one (Transect 3) of the three renourished transects on which statistical comparisons were performed, but the difference was not statistically significant. The Δ_b for waterbird richness was significantly lower than Δ_a at Transect 3, but temporal patterns in post-nourishment Δs do not suggest the difference was due to renourishment activity.

The Δ_b for shorebird abundance was higher than Δ_a at two of the three renourished transects (2 and 5) on which statistical comparisons were performed, but at no transect was the difference statistically significant. The Δ_b for shorebird richness was also greater than Δ_a at all three renourished transects, but no difference was statistically significant. The power for all statistical comparisons regarding the effects of renourishment was generally low, indicating that additional surveys or data will be required prior to confident conclusions.

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FIGURES

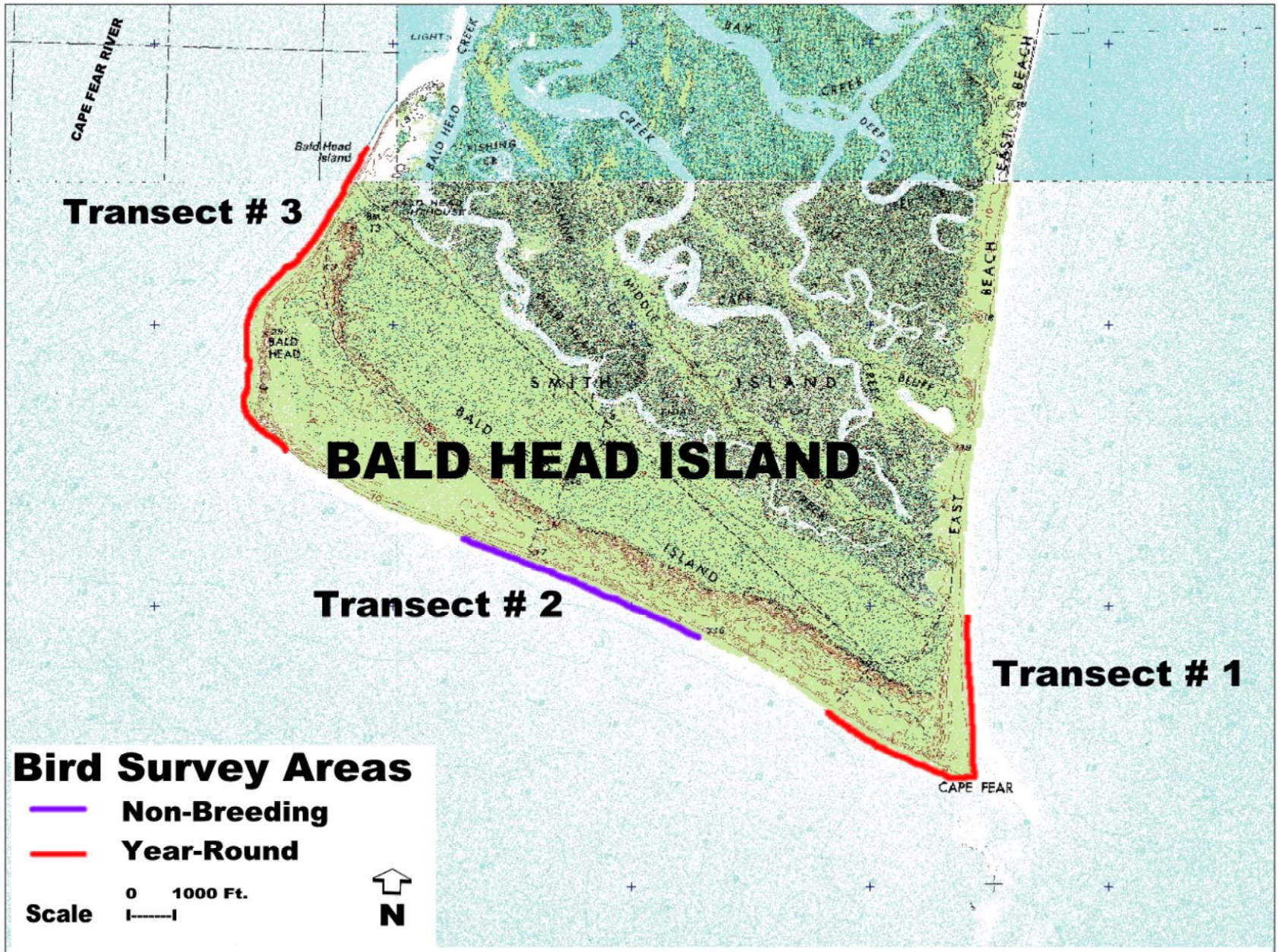

Figure 1. Location of Transects 1 through 3 on Bald Head Island, Brunswick County, N.C.

3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 1000 ft Scale: 1 : 34,375 Detail: 13-0 Datum: WGS84

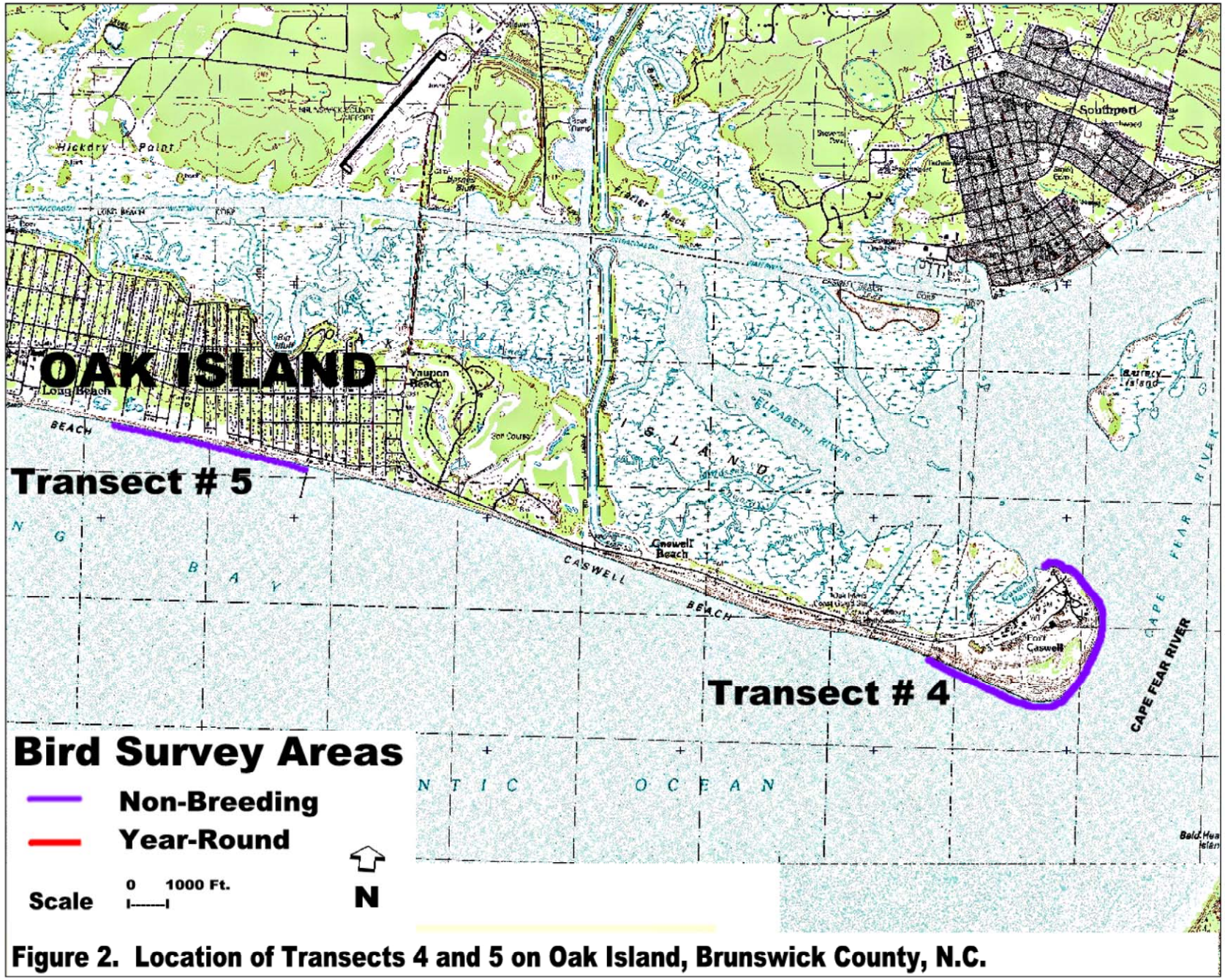

Figure 2. Location of Transects 4 and 5 on Oak Island, Brunswick County, N.C.

3-D Topo Quads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 1000 ft Scale: 1 : 40,625 Detail: 13-0 Datum: WGS84

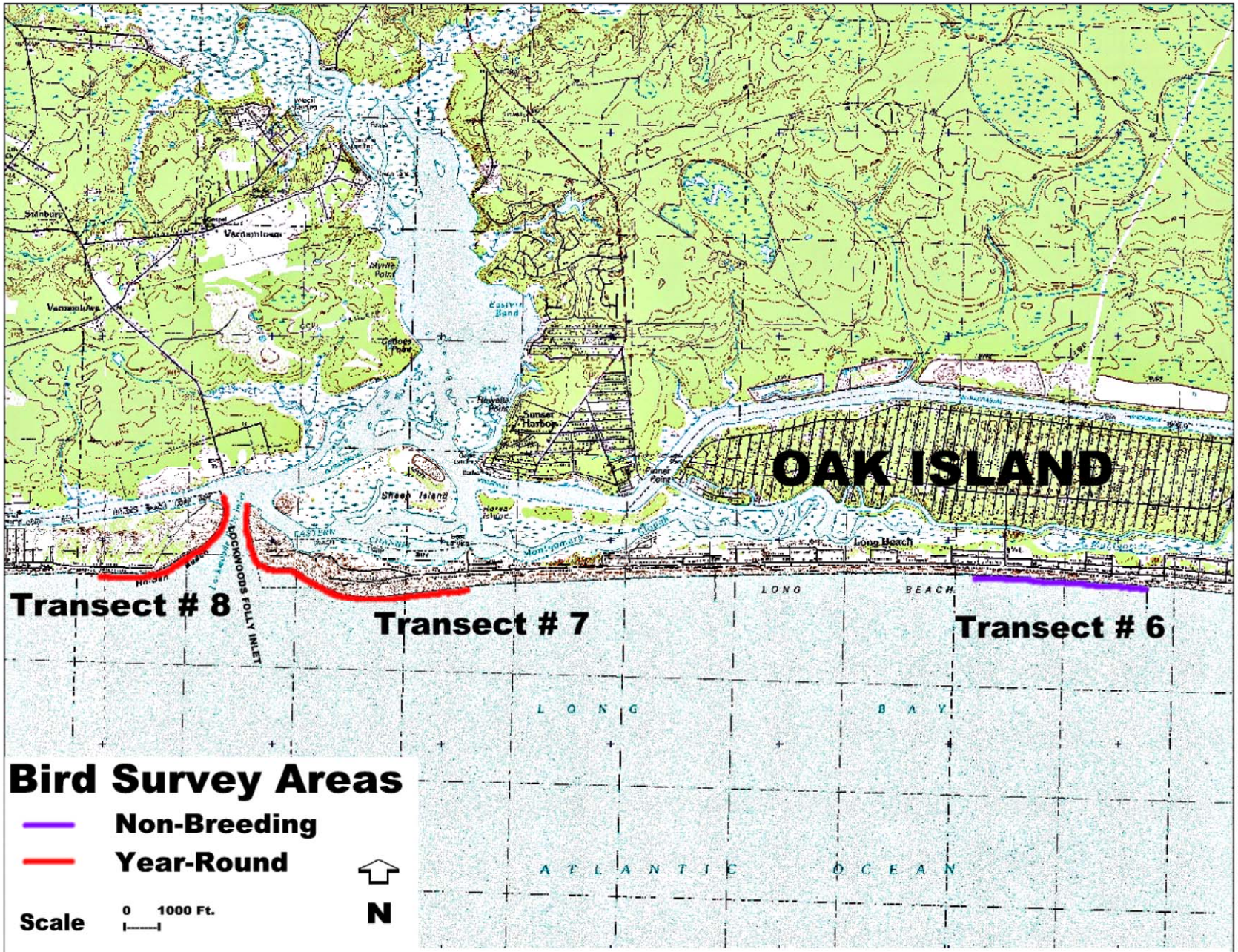

Figure 3. Location of Transects 6 through 8 on Oak Island and Holden Beach, Brunswick County, N.C.

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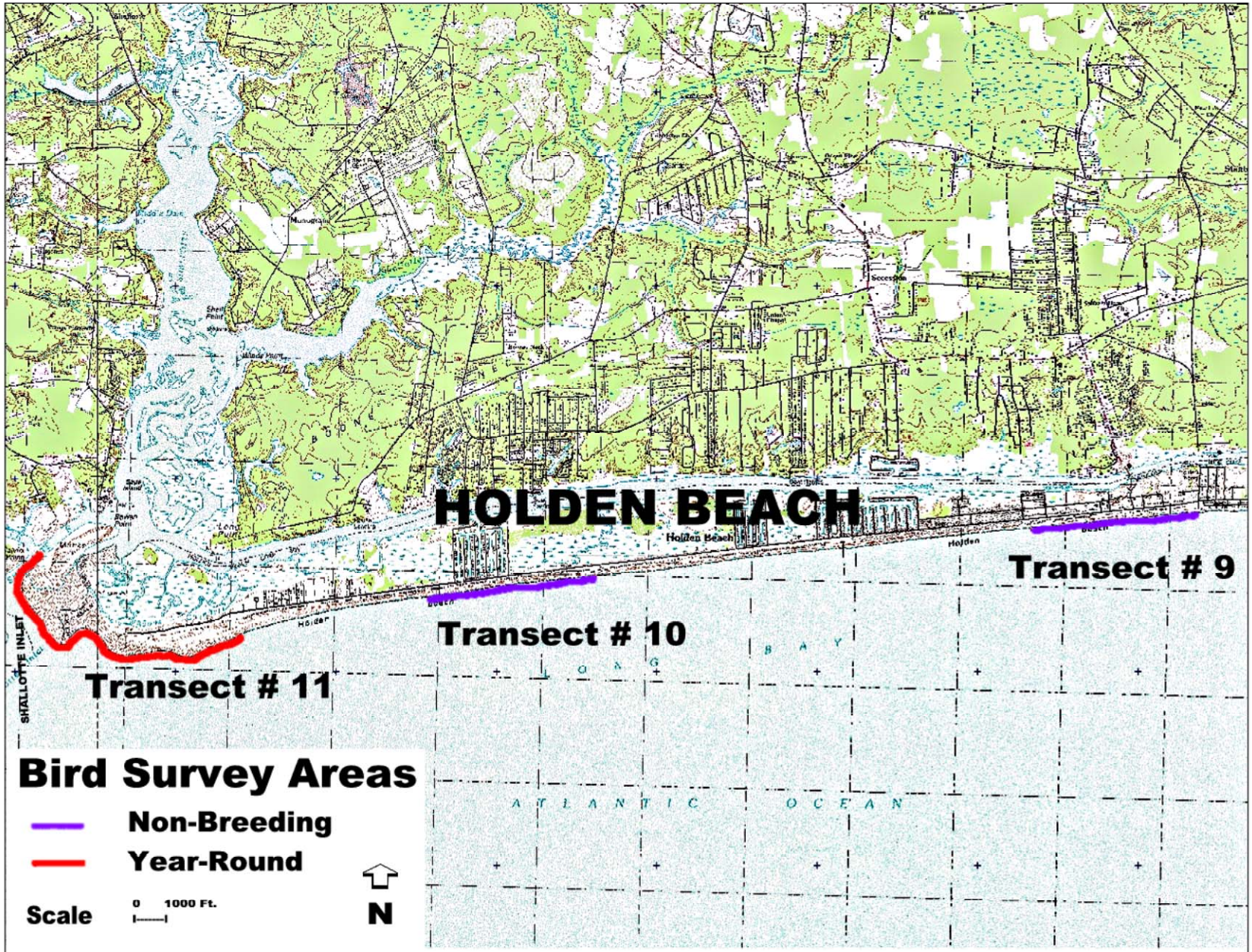

Figure 4. Location of Transects 9 through 11 on Holden Beach, Brunswick County, N.C.

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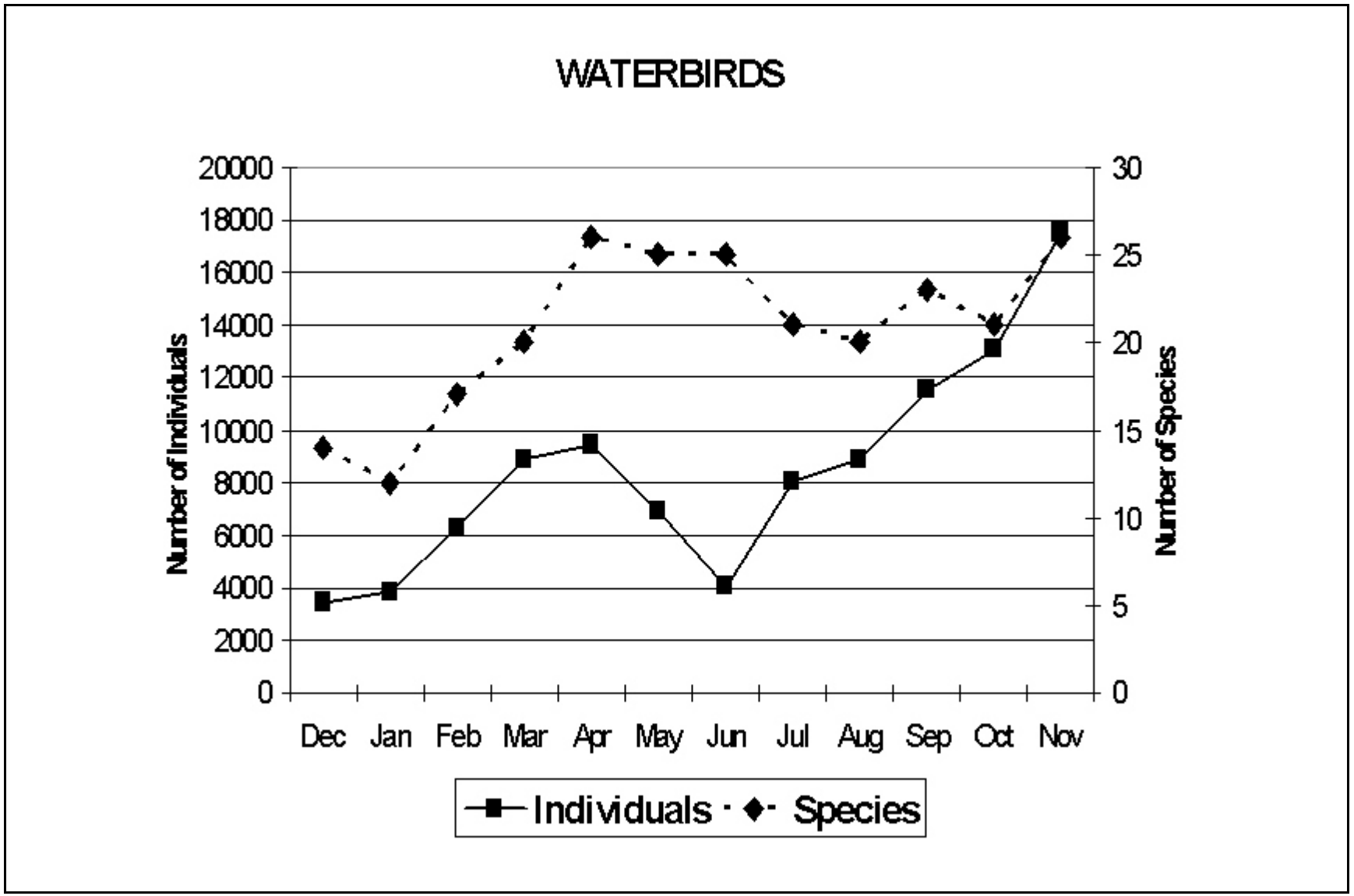


FIGURE 5. Monthly abundance and species richness of waterbirds for Transects 1 through 11.

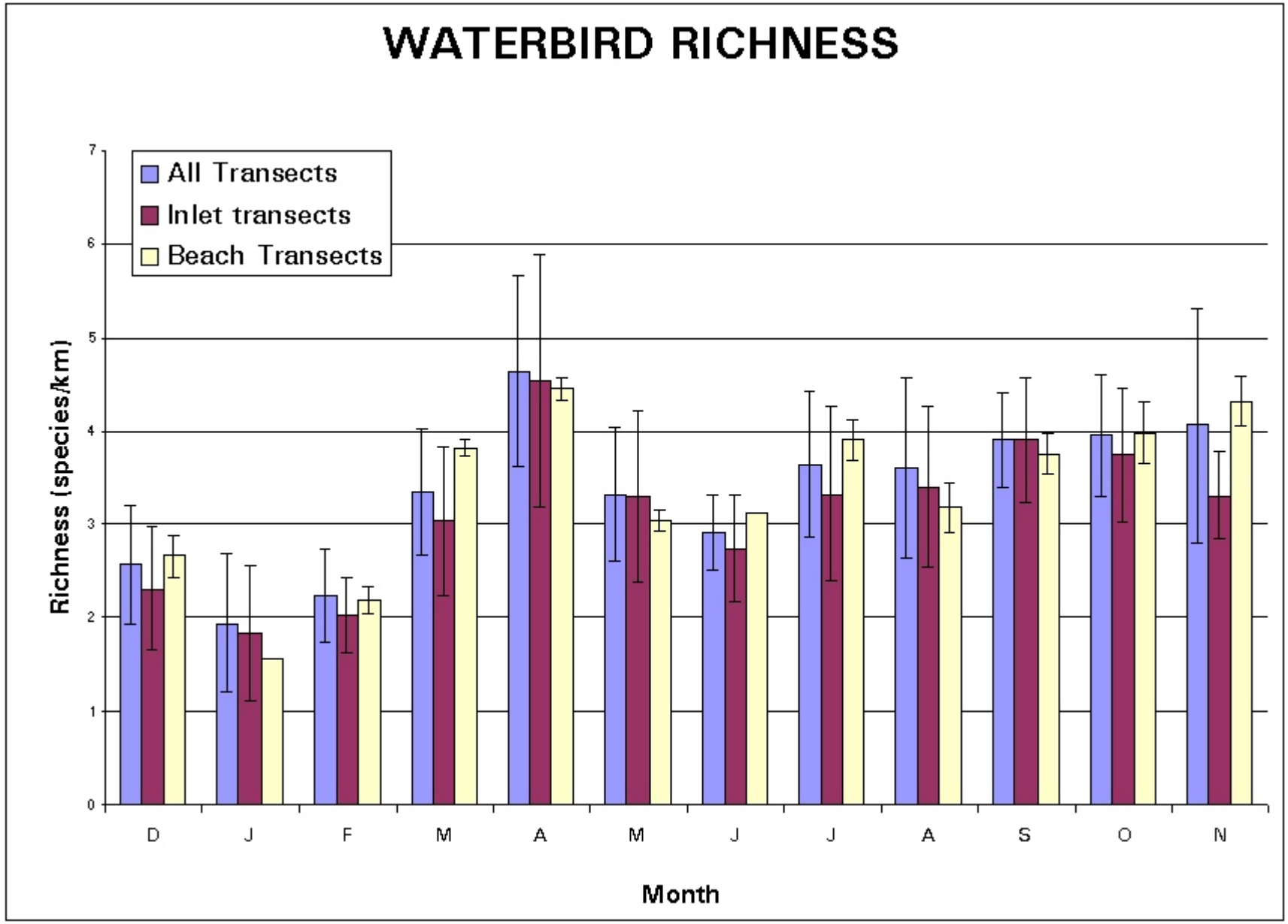


FIGURE 6. Mean (and one standard deviation) monthly waterbird richness at unnourished transects.

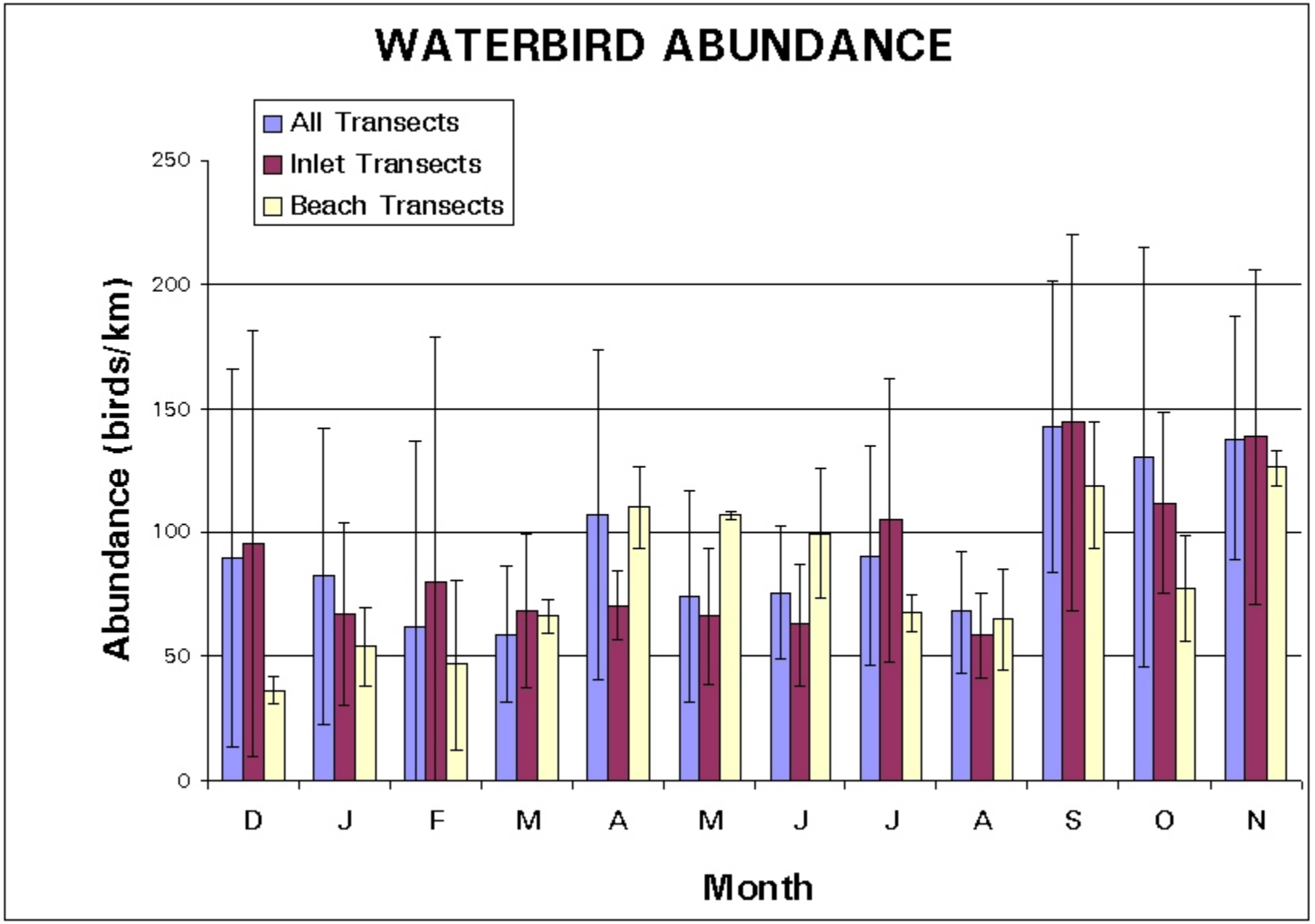


FIGURE 7. Mean (and one standard deviation) monthly waterbird abundance at unnourished transects.

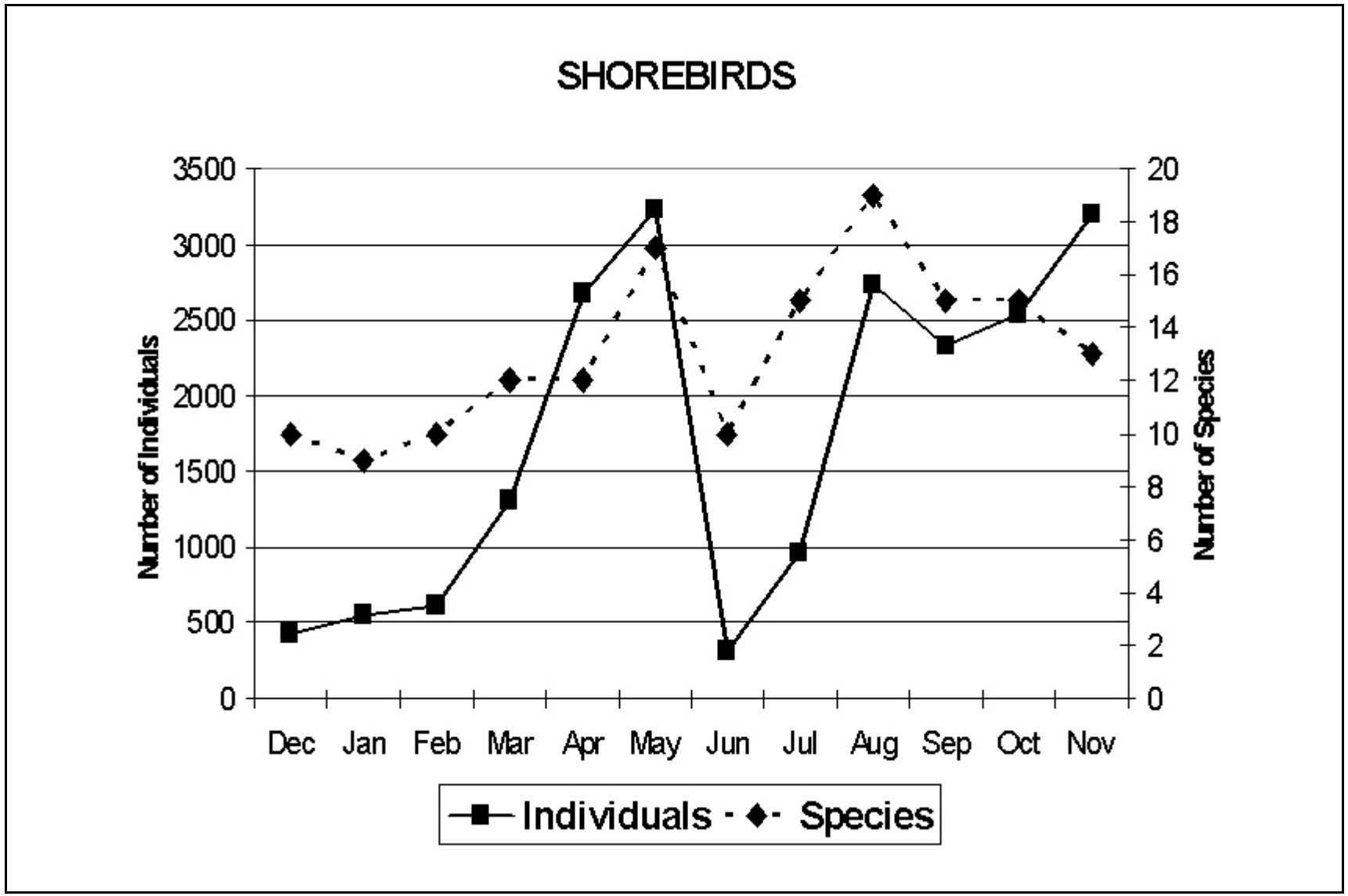


FIGURE 8. Monthly abundance and species richness of shorebirds for Transects 1 through 11.

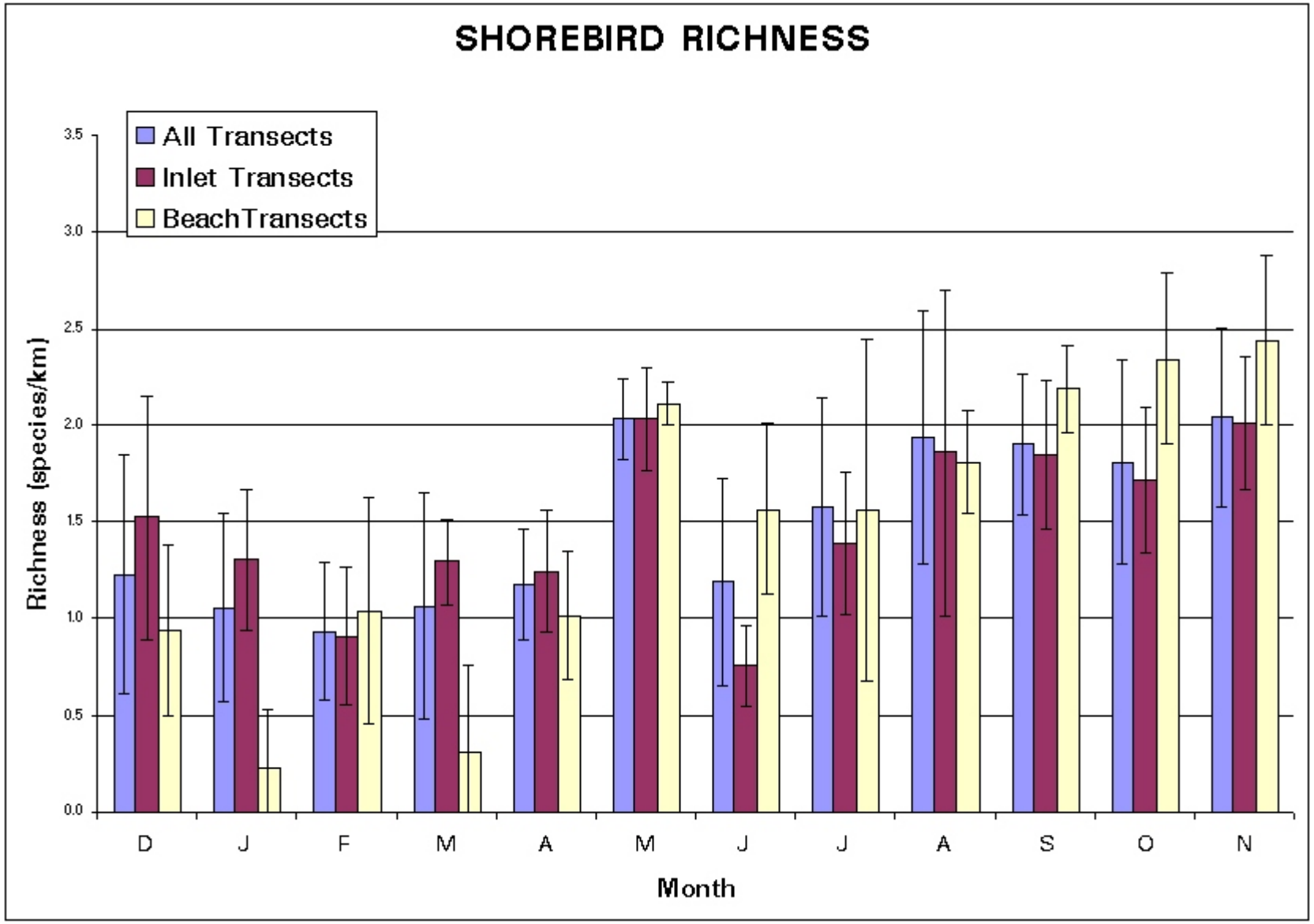


FIGURE 9. Mean (and one standard deviation) monthly shorebird richness at unnourished transects.

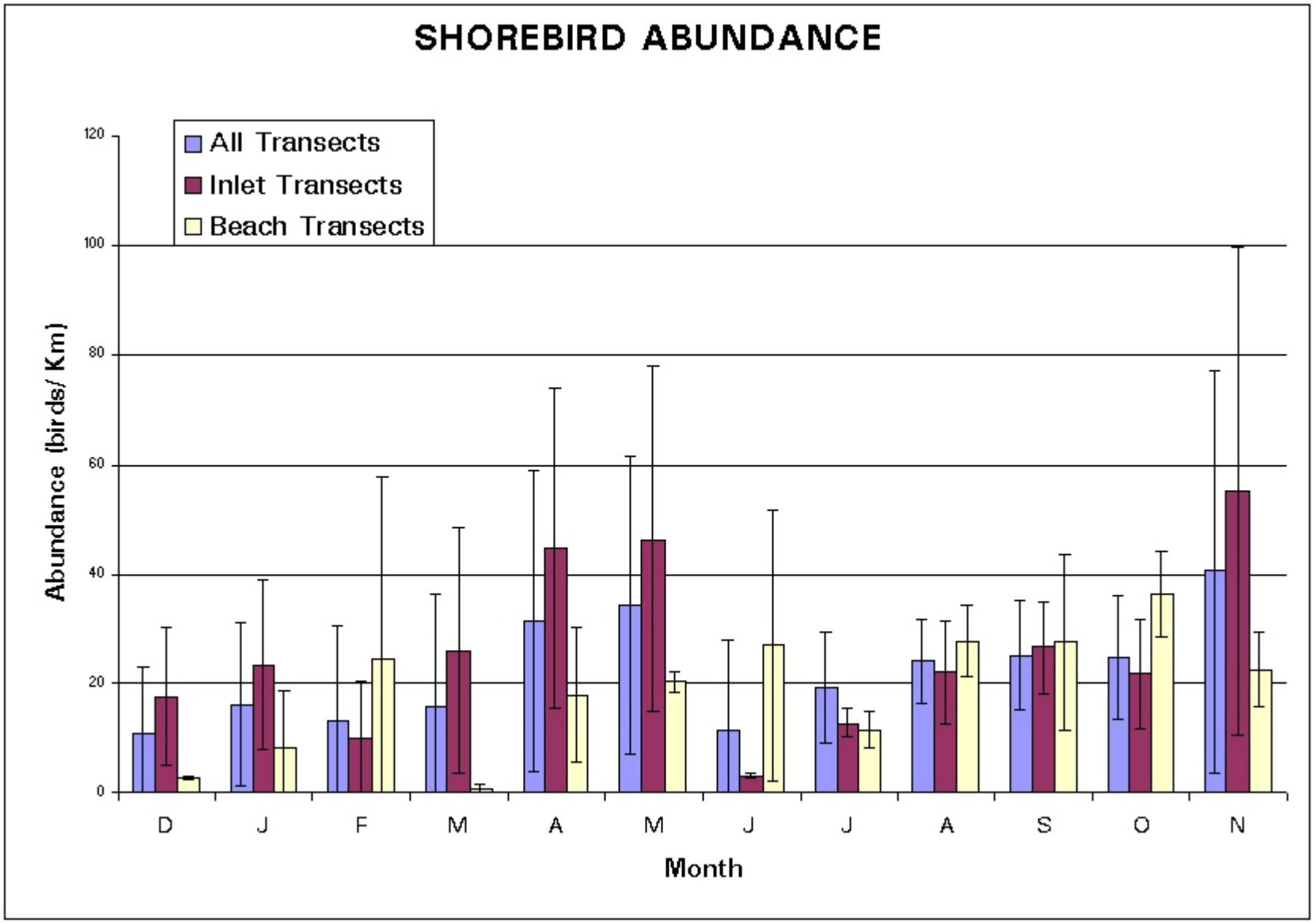


FIGURE 10. Mean (and one standard deviation) monthly shorebird abundance at unnourished transects.

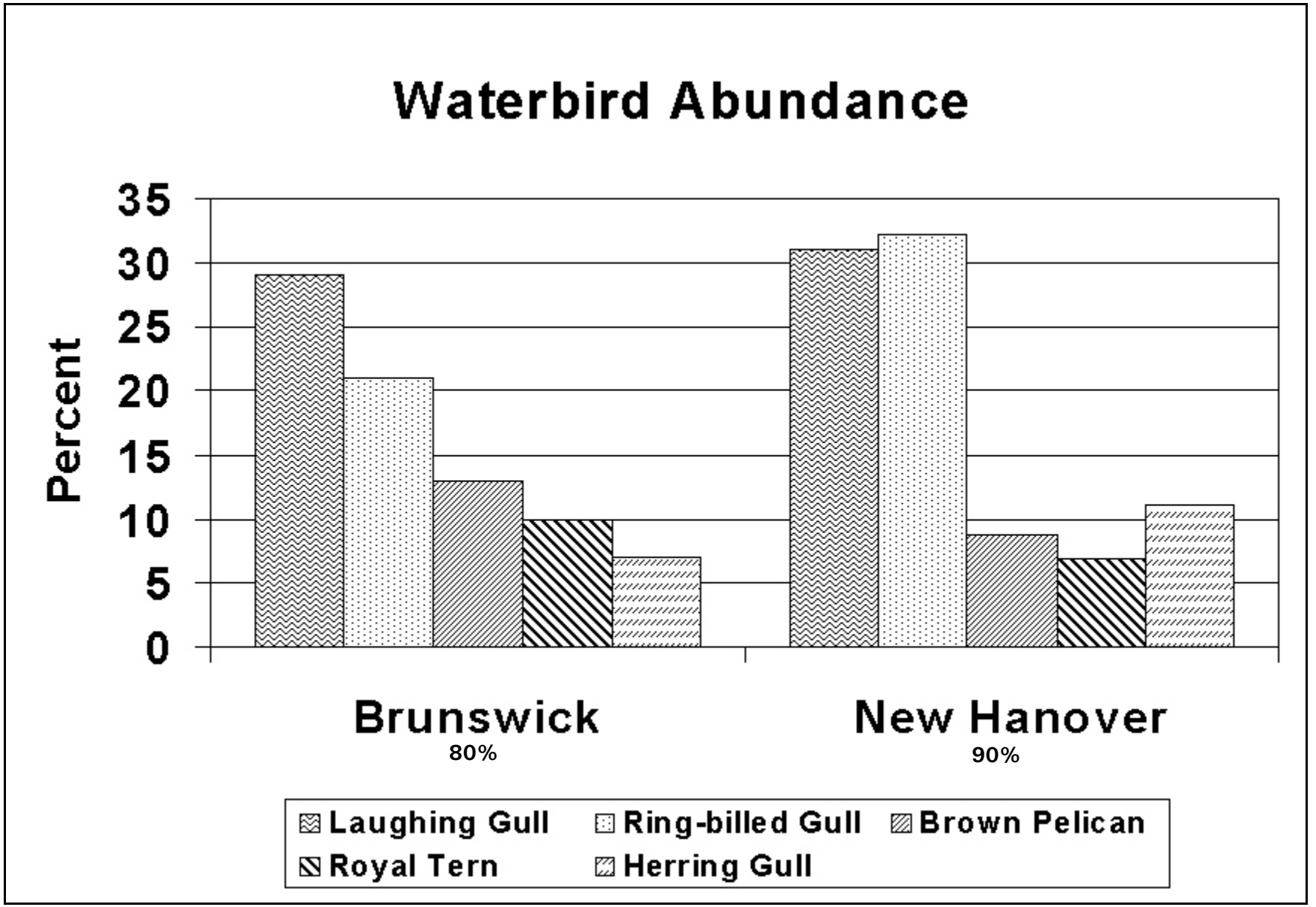


FIGURE 11. Five most abundant (percentage of total recorded) waterbirds from Brunswick County (this study) and in New Hanover County (Smith 1988).

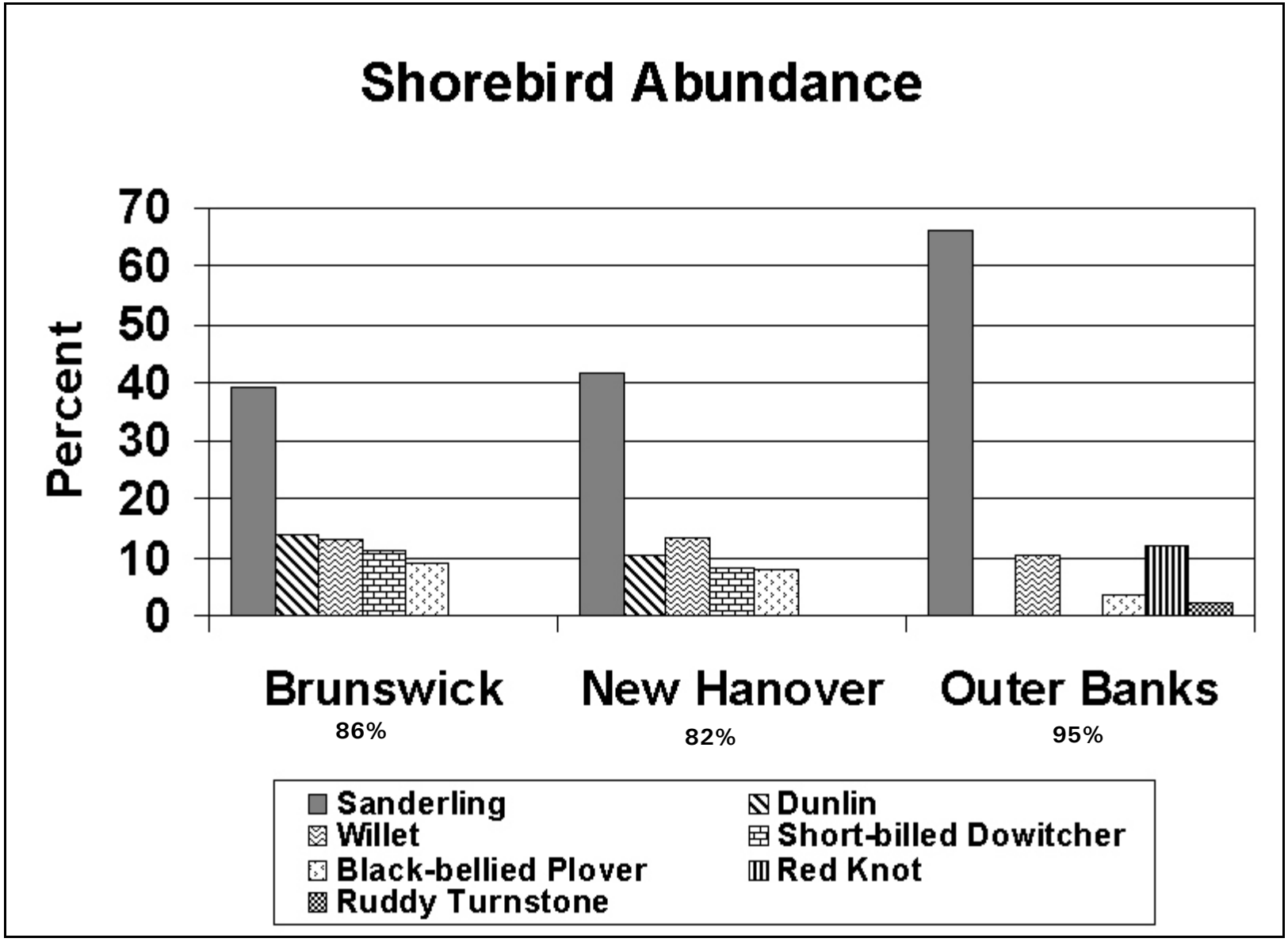


FIGURE 12. Five most abundant (percentage of total recorded) shorebirds from Brunswick County (this study), in New Hanover County (Smith 1988), and on the Outer Banks of N.C. (Dinsmore et al., 1998).

TABLES

Table 1. Summary of transect locations, features, and characteristics for Brunswick County bird surveys.

Transect #	Island	Site	Length (km)	# of Surveys	Frequency of surveys	Renourishment
1	Bald Head	Cape	1.6	47	year-round	—
2	Bald Head	Beach	1.6	41	non-breeding	May-June 2001
3	Bald Head	Inlet/river	2.4	47	year-round	Feb.-May 2001 (partial)
4	Oak Island	Inlet/river	2.4	41	non-breeding	—
5	Oak Island	Beach	1.6	41	non-breeding	Sept.-Oct. 2001
6	Oak Island	Beach	1.6	41	non-breeding	—
7	Oak Island	Inlet	2.4	47	year-round	—
8	Holden Beach	Inlet	1.6	47	year-round	—
9	Holden Beach	Beach	1.6	41	non-breeding	—
10	Holden Beach	Beach	1.6	41	non-breeding	—
11	Holden Beach	Inlet	3.2	47	year-round	—

Table 2. Total waterbird individuals recorded for each species in each transect.

	Transect #											
Species	1	2	3	4	5	6	7	8	9	10	11	Grand Total
Laughing Gull	1,021	1,978	3,100	1,074	3,714	3,060	3,207	2,463	2,483	1,928	2,056	26,084
Ring-billed Gull	1,281	653	1,807	509	3,324	3,162	1,742	1,241	2,102	1,646	1,599	19,066
Brown Pelican	1,999	473	906	1,445	1,125	890	1,269	915	638	626	1,464	11,750
Royal Tern	2,831	186	2,684	690	85	42	753	826	33	66	872	9,068
Herring Gull	894	162	567	795	408	447	1,101	477	248	240	998	6,337
Forster's Tern	128	133	525	237	304	347	938	364	312	183	828	4,299
Double-crested Cormorant	141	71	82	2,748	30	19	91	573	18	57	200	4,030
Sandwich Tern	981	83	626	52	16	2	401	303	13	7	240	2,724
Bonaparte's Gull	123	654	61	10	5	41	102	13	206	120	10	1,345
Black Skimmer	0	0	0	7	0	0	727	418	18	2	101	1,273
Great Black-backed Gull	65	16	62	59	54	60	199	53	44	64	384	1,060
Common Tern	360	3	82	20	2	0	38	160	5	6	310	986
Least Tern	313	28	218	34	4	0	37	180	5	5	32	856
Caspian Tern	181	24	83	112	33	15	71	106	12	23	122	782
White Ibis	0	12	137	86	1	2	73	0	8	0	338	657
Northern Gannet	124	13	38	26	20	13	13	19	24	25	3	318
Black Tern	30	0	7	0	0	0	0	98	1	0	7	143
Red-breasted Merganser	0	0	0	13	0	0	2	1	0	0	40	56
Red-throated Loon	11	3	17	6	3	0	3	3	0	1	6	53
Black Scoter	0	26	0	0	0	0	0	1	0	0	8	35
Great Blue Heron	5	0	0	11	1	0	0	3	0	0	4	24
Snowy Egret	2	1	5	0	1	0	2	1	0	0	5	17
Gull-billed Tern	0	0	0	2	0	0	7	2	0	0	4	15
Glossy Ibis	0	0	3	2	0	0	0	0	0	0	8	13
Great Egret	0	0	1	2	0	0	0	1	0	0	7	11
Lesser Black-backed Gull	3	0	2	0	0	0	1	0	1	0	2	9
Common Loon	1	0	1	3	0	0	1	0	1	0	2	9
Tricolored Heron	0	0	0	2	1	0	0	2	0	0	2	7
Horned Grebe	0	0	0	0	0	0	0	1	0	0	4	5
Surf Scoter	0	0	0	0	0	0	0	0	0	4	0	4
Wood Stork	0	0	0	0	0	0	0	0	0	0	3	3
Little Blue Heron	0	0	1	0	0	0	0	1	0	0	0	2

Table 2. (concluded)

	Transect #											
Species	1	2	3	4	5	6	7	8	9	10	11	Grand Total
Mallard	0	0	0	2	0	0	0	0	0	0	0	2
Green Heron	0	0	0	0	0	0	0	0	0	0	1	1
Parasitic Jaeger	1	0	0	0	0	0	0	0	0	0	0	1
Greater Shearwater	1	0	0	0	0	0	0	0	0	0	0	1
Great Cormorant	0	0	0	0	0	1	0	0	0	0	0	1
Hooded Merganser	0	0	0	0	0	0	0	0	1	0	0	1
Pomarine Jaeger	1	0	0	0	0	0	0	0	0	0	0	1
Iceland Gull	0	0	0	0	0	0	0	1	0	0	0	1
Total individuals	10,497	4,519	11,015	7,947	9,131	8,101	10,778	8,226	6,173	5,003	9,660	91,050
Total species	23	18	23	25	19	14	22	29	20	17	31	41

Table 3. Waterbird richness and abundance.

Site	Transect	Species	Average number of species/survey	Average number of birds/km/survey
Cape	1	**23**	**6.9**	**138.8**
Beach	2[a]	18	5.2	65.5
	5[a]	19	5.8	138.4
	6	14	4.8	122.8
	9	20	5.6	93.6
	10	17	5.7	75.8
	13[a,b]	22	6.9	90.5
	Average	**18.3**	**5.7**	**97.8**
Inlet	3[a]	23	7.2	97.1
	4	25	7.7	80.3
	7	22	7.4	95.0
	8	29	6.6	108.8
	11	31	8.2	63.9
	12[a,b]	27	8.6	86.4
	Average	**26.2**	**7.6**	**88.6**

[a] Renourished during 2001.
[b] Transect at Ocean Isle.

Table 4. Most abundant waterbirds per survey per km (Transects #1 through 11).

Waterbird species	Cape	Beach	Inlet
Laughing Gull	13.6	40.1	21.1
Ring-billed Gull	17.0	33.2	12.2
Royal Tern	37.6	1.3	10.3
Brown Pelican	26.6	11.4	10.6
Herring Gull	11.9	4.6	7.0
Sandwich Tern	13.0	0.4	2.9
Forster's Tern	1.7	3.9	5.1
Double-crested Cormorant	1.9	0.6	6.5
Common Tern	4.8	0.1	1.1
Least Tern	4.2	0.1	0.9

Table 5. Total numbers of shorebird individuals recorded for each species in each transect.

	Transect #											
Species	1	2	3	4	5	6	7	8	9	10	11	Grand Total
Sanderling	551	222	958	1,106	361	440	947	542	734	753	913	7,527
Dunlin	0	0	61	1,151	2	0	821	65	0	5	614	2,719
Willet	210	81	305	76	88	175	685	174	177	294	310	2,575
Short-billed Dowitcher	10	0	210	296	1	2	331	22	1	350	790	2,013
Black-bellied Plover	10	11	184	522	17	48	271	55	42	75	416	1,651
Semipalmated Plover	14	0	12	30	58	4	356	38	4	18	566	1,100
Ruddy Turnstone	17	23	73	50	34	33	104	86	79	79	49	627
Semipalmated Sandpiper	3	4	0	7	15	0	0	107	25	0	73	234
Whimbrel	115	0	5	2	9	3	21	1	4	2	15	177
Killdeer	9	8	45	4	5	3	4	26	3	2	9	118
Wilson's Plover	17	2	23	3	0	0	19	4	1	1	27	97
Piping Plover	10	0	3	26	4	0	3	7	0	2	19	74
American Oystercatcher	0	0	0	23	1	0	1	1	0	1	21	48
Least Sandpiper	0	0	1	0	0	0	0	22	0	0	24	47
Red Knot	0	0	0	2	0	0	22	0	0	0	17	41
Long-billed Dowitcher	0	0	0	13	0	0	2	0	0	0	6	21
Marbled Godwit	0	0	0	0	0	0	20	0	0	0	0	20
Greater Yellowlegs	0	0	0	2	0	0	4	1	0	0	13	20
Western Sandpiper	1	0	0	16	0	0	0	0	0	0	0	17
Common Snipe	0	0	0	15	0	0	0	0	0	0	0	15
Solitary Sandpiper	0	0	0	0	0	0	4	0	0	0	1	5
Pectoral Sandpiper	0	0	0	0	1	0	0	0	0	0	3	4
Spotted Sandpiper	0	0	3	0	0	0	0	1	0	0	0	4
Lesser Yellowlegs	1	0	0	0	0	0	1	0	0	0	0	2
Total individuals	968	351	1,883	3,344	596	708	3,616	1,152	1,070	1,582	3,886	19,156
Total species	13	7	13	18	13	8	18	16	10	12	19	24

Table 6. Shorebird richness and abundance.

Site	Transect	Species	Average number of species/survey	Average number of birds/km/survey
Cape	1	**13**	**2.5**	**12.8**
Beach	2[a]	7	1.7	5.3
	5[a]	13	2.2	9.0
	6	8	2.1	10.7
	9	10	2.3	16.2
	10	12	2.7	24.0
	13[a,b]	8	2.5	10.6
	Average	**9.7**	**2.3**	**12.6**
Inlet	3[a]	13	3.1	16.6
	4	18	3.9	33.8
	7	18	3.6	31.9
	8	16	2.7	15.2
	11	19	4.1	25.7
	12[a,b]	17	4.3	16.9
	Average	**16.8**	**3.6**	**23.4**

[a] Renourished during 2001.
[b] Transect at Ocean Isle.

Table 7. Most abundant shorebirds per survey per km (Transects #1 through 11).

Waterbird species	Cape	Beach	Inlet
Sanderling	7.3	7.7	7.9
Willet	2.8	2.5	2.7
Dunlin	0.0	0.0	4.8
Short-billed Dowitcher	0.1	1.1	2.9
Black-bellied Plover	0.2	0.3	1.8
Semipalmated Plover	0.1	0.6	2.6
Whimbrel	1.5	0.1	0.1
Ruddy Turnstone	0.2	0.8	0.6
Semipalmated Sandpiper	0.0	0.1	0.3
Killdeer	0.1	0.1	0.2

Table 8. Percentage of total waterbird individuals recorded by habitat and transect.

Site	Transect	Intertidal	Beach	Dune
Cape	1	**79.7**	**17.8**	**2.5**
Beach	2[a]	81.7	12.3	6.0
	5[a]	58.0	29.7	12.3
	6	66.3	17.7	16.0
	9	57.6	26.0	16.4
	10	55.4	25.9	18.8
	13[a,b]	58.3	22.1	19.6
Average		**62.9**	**22.3**	**14.8**
Inlet	3[a]	68.0	25.8	6.3
	4	91.7	2.9	5.5
	7	64.0	20.6	15.4
	8	78.6	11.7	9.7
	11	81.3	9.8	8.9
	12[a,b]	90.1	2.4	7.6
Average		**79.0**	**12.2**	**8.8**

[a] Renourished during 2001.
[b] Transect at Ocean Isle.

Table 9. Percentage of total shorebird individuals recorded by habitat and transect.

Site	Transect	Intertidal	Beach	Dune
Cape	1	**89.1**	**9.6**	**1.3**
Beach	2[a]	91.2	7.4	1.4
	5[a]	95.0	4.9	0.2
	6	92.4	7.6	0.0
	9	86.4	10.2	3.5
	10	73.2	25.5	1.3
	13[a,b]	92.0	4.8	3.2
Average		**88.4**	**10.1**	**1.6**
Inlet	3[a]	74.2	23.7	2.1
	4	80.4	17.2	2.5
	7	55.2	43.5	1.3
	8	85.0	13.0	2.0
	11	61.8	35.0	3.3
	12[a,b]	83.8	11.7	4.5
Average		**73.4**	**24.0**	**2.6**

[a] Renourished during 2001.
[b] Transect at Ocean Isle.

Table 10. Percentage of total waterbird individuals recorded by activity and transects.

Site	Transect	Resting	Feeding	Flying	Breeding
Cape	1	**10.5**	**60.7**	**28.8**	**0.00**
Beach	2[a]	13.2	37.4	49.3	0.09
	5[a]	6.2	51.9	41.8	0.11
	6	9.3	46.9	43.8	0.00
	9	12.7	40.8	46.4	0.05
	10	13.9	30.7	55.4	0.04
	13[a,b]	12.6	25.3	62.1	0.00
	Average	**11.3**	**38.8**	**49.8**	**0.05**
Inlet	3[a]	6.8	61.9	30.9	0.42
	4	6.5	57.0	36.5	0.00
	7	8.4	42.9	48.7	0.00
	8	9.4	47.4	43.1	0.00
	11	6.9	48.0	45.1	0.00
	12[a,b]	8.7	45.0	46.3	0.00
	Average	**7.8**	**50.4**	**41.8**	**0.07**

[a] Renourished during 2001.
[b] Transect at Ocean Isle.

Table 11. Percentage of total shorebird individuals recorded by activity and transect.

Site	Transect	Resting	Feeding	Flying	Breeding
Cape	1	**64.8**	**12.1**	**22.5**	**0.62**
Beach	2[a]	79.8	9.4	10.8	0.00
	5[a]	78.5	14.7	6.9	0.00
	6	86.9	8.5	4.7	0.00
	9	78.8	12.4	8.8	0.00
	10	62.9	32.1	5.0	0.13
	13[a,b]	65.3	17.9	16.8	0.00
	Average	**75.3**	**15.8**	**8.8**	**0.02**
Inlet	3[a]	44.1	50.0	4.7	1.17
	4	27.1	64.5	8.4	0.00
	7	38.7	53.0	8.3	0.03
	8	63.9	13.8	22.2	0.09
	11	33.6	58.2	7.7	0.54
	12[a,b]	33.2	51.0	13.7	2.10
	Average	**40.1**	**48.4**	**10.8**	**0.66**

[a] Renourished during 2001.
[b] Transect at Ocean Isle.

Table 12. Signs of breeding birds along Transects 1 through 11, Brunswick County, N.C. during 2001.

Species	Island	location	Lat./Long.[a]	Transect	Comments
Wilson's Plover	Bald Head	Cape Fear Pt.	33 50'37.00052"N 77 57'52.33679"W	1 W-M	Nest with 3 eggs 15 -25 19 June; 2 young seen in July
Wilson's Plover	Bald Head	Cape Fear River	33 52'03.81020"N 78 00'36.02618"W	3 E-M	Pair with 2 young (out of nest but unable to fly) on 15 June
Wilson's Plover	Oak Island	Lockwoods Folly Inlet	33 54'56.89202"N 78 14'09.32732"W	7 W	One chick seen 4-17 July
Wilson's Plover	Holden Beach	Lockwoods Folly Inlet	33 55'01.58545"N 78 14'23.47582"W	8 E	Suspected nesting attempt. Only found once during the nesting season, but it was a female feigning a broken wing on 1 June.
Wilson's Plover	Holden Beach	Shallotte Inlet	33 54'20.49858"N 78 22'51.96889"W	11 W-M	Suspected nesting. Pair on territory from mid April through mid June. Immature bird seen on 16 June.
Willet	Holden Beach	Shallotte Inlet	33 54'11.85011"N 78 21'44.91437"W	11 E	Pair suspected nesting along marsh edge, behind island on several dates.
Willet	Holden Beach	Shallotte Inlet	33 54'23.71210"N 78 22'49.88868"W	11 W-M	Two pairs suspected nesting along marsh edge behind island on several dates.
Least Tern	Bald Head	Cape Fear River	33 52'04.22600"N 78 00'35.79211"W	3 E-M	Up to 6 birds on territory from 12 May - 10 July in designated/marked tern nesting area. One nest with 3 eggs on 6 June and with 2 young/1 egg on 15 June.
Least Tern	Bald Head	Cape Fear River	33 52'03.81020"N 78 00'36.02618"W	3 E-M	One nest with 2 eggs on 15 and 19 June.

[a] Nest locations or approximate nesting sites were determined with Trimble PRO XR GPS unit.

Table 13. Summary of recorded disturbances for each transect.

	Transect #										
Type of disturbance	1	2	3	4	5	6	7	8	9	10	11
Humans	39	33	43	21	39	38	42	43	35	33	42
Pets	10	13	9	1	11	6	14	8	3	9	7
Number of surveys	47	41	47	41	41	41	47	47	41	41	47
Average number of perople per survey	11.91	11.76	10.4	7.93	53.61	40.54	28.36	28.36	48.73	58.46	30.43
Percent of surveys with a disturbance	82.98	80.49	91.49	51.22	95.12	92.68	91.49	91.49	85.37	80.49	89.36
Percent of disturbances with a pet	25.64	39.39	20.93	4.76	28.21	15.79	18.6	18.6	8.57	27.27	16.67

Table 14 . Comparison of waterbird abundance at low and high tide for cape, inlet, and beach transects.

Transect description	Transect	Mean low tide abundance (± SD)	Mean high tide abundance (± SD)	*p* value
Cape	1	103.2 ± 134.7	171.6 ± 191.6	**0.049** [a]
Inlet	4	39.3 ± 26.3	110.3 ± 117.3	**0.002** [a]
Inlet	7	85.9 ± 94.4	105.60 ± 96.9	0.233 [a]
Inlet	8	83.7 ± 78.5	131.9 ± 152.8	0.798
Inlet	11	55.1 ± 40.0	75.6 ± 75.5	0.708 [a]
Beach	9	109.7 ± 60.2	76.1 ± 35.6	0.058 [a]
Beach	10	75.2 ± 53.0	77.64 ± 35.5	0.867

[a] Comparison used a Wilcoxon Rank Sum test.

Table 15. Comparison of waterbird richness at low and high tide for cape, inlet, and beach transects.

Transect description	Transect	Mean low tide abundance (± SD)	Mean high tide abundance (± SD)	*p* value
Cape	1	4.92 ± 1.18	4.60 ± 1.75	0.241 [a]
Inlet	4	2.92 ± 1.09	3.39 ± 0.87	0.126
Inlet	7	2.92 ± 0.92	3.28 ± 0.83	0.268 [a]
Inlet	8	4.06 ± 1.23	4.23 ± 1.58	0.696
Inlet	11	2.52 ± 0.66	2.60 ± 0.91	0.822 [a]
Beach	9	3.72 ± 0.81	3.19 ± 1.06	0.147 [a]
Beach	10	3.67 ± 1.05	3.33 ± 1.07	0.322

[a] Comparison used a Wilcoxon Rank Sum test.

Table 16. Comparison of shorebird abundance at low and high tide for cape, inlet, and beach transects.

Transect description	Transect	Mean low tide abundance (± SD)	Mean high tide abundance (± SD)	*p* value
Cape	1	12.7 ± 25.9	13.0 ± 13.3	0.963
Inlet	4	7.92 ± 9.9	52.5 ± 49.78	**< 0.001**
Inlet	7	17.7 ± 33.6	47.1 ± 62.9	**0.043** [a]
Inlet	8	7.5 ± 7.5	22.2 ± 18.51	**0.002** [a]
Inlet	11	10.07 ± 15.8	45.4 ± 67.3	**0.018** [a]
Beach	9	19.0 ± 14.7	13.3 ± 12.8	0.266 [a]
Beach	10	22.7 ± 20.7	25.87 ± 33.4	0.937

[a] Comparison used a Wilcoxon Rank Sum test.

Table 17. Comparison of shorebird richness at low and high tide for cape, inlet, and beach transects.

Transect description	Transect	Mean low tide abundance (± SD)	Mean high tide abundance (± SD)	*p* value
Cape	1	1.6 ± 0.86	1.5 ±0.69	0.773 [a]
Inlet	4	1.08 ± 0.56	2.03 ± 0.80	**< .001**
Inlet	7	1.35 ± 0.79	1.65 ± 1.02	0.271
Inlet	8	1.34 ± 0.72	2.05 ± 1.15	**0.048** [a]
Inlet	11	0.94 ± 0.53	1.71 ± 0.93	**< .001** [a]
Beach	9	1.51 ± 1.11	1.32 ± 0.81	0.548
Beach	10	1.74 ± 0.89	1.67 ± 0.98	0.895 [a]

[a] Comparison used a Wilcoxon Rank Sum test.

Table 18. T-test comparisons of pre- and post-nourishment △ (renourished transect - control) for abundance of waterbirds. P values in bold represent significant differences in $\triangle_b$ and $\triangle_a$ (α = .05). All abundance values were log (x +.1) transformed.

Beach transects		Number of surveys					
Transect	Site	Before	After	$\triangle_b$	$\triangle_a$	*p* value	Power
2	Beach	18	20	-28.10	-18.72	0.104	0.241
5	Beach	6[a]	7	6.35	228.5	0.279	0.076
3	Inlet	6	30	-5.47	-11.25	0.309	.054

[a] Data were non-additive if all before sampling dates were used. Therefore only week 28 to 33 were included in the before period.
[b] Compared using Wilcoxon Rank sum test.

Table 19. T-test comparisons of pre- and post-nourishment △ (renourished transect - control) for richness of waterbirds. P values in bold represent significant differences in $\triangle_b$ and $\triangle_a$ (α = .05).

Beach transects		Number of surveys					
Transect	Site	Before	After	$\triangle_b$	$\triangle_a$	*p* value	Power
2	Beach	18	20	-0.42	-0.125	0.492[b]	na
5	Beach	6[a]	7	- 0.37	0.67	0.073[b]	na
3	Inlet	6	30	0.40	-0.45	**0.022**	0.588

[a] Data were non-additive if all before sampling dates were used. Therefore only week 28 to 33 were included in the before period.
[b] Compared using Wilcoxon Rank sum test.

Table 20. T-test comparisons of pre- and post-nourishment △ (renourished transect - control) for abundance of shorebirds. P values in bold represent significant differences in $\triangle_b$ and $\triangle_a$ (α = .05). All abundance values were log (x +.1) transformed.

Beach transects		Number of surveys					
Transect	Site	Before	After	$\triangle_b$	$\triangle_a$	*p* value	Power
2	Beach	18	20	-8.96	-21.125	no test [b]	NA
5	Beach	6[a]	7	-10.7	-20.48	0.101 [c]	na
3	Inlet	6	30	-10.54	-3.48	0.350	0.050

[a] Only week 28 to 33 were included in the before period.
[b] Before period △s were non-additive therefore no test was performed.
[c] Compared using Wilcoxon Rank sum test.

Table 21. T-test comparisons of pre- and post-nourishment △ (renourished transect - control) for richness of shorebirds. P values in bold represent significant differences in $\triangle_b$ and $\triangle_a$ (α = .05).

Beach transects		Number of surveys					
Transect	Site	Before	After	$\triangle_b$	$\triangle_a$	*p* value	Power
2	Beach	18	20	0.00	-1.03	no test [b]	NA
5	Beach	6[a]	7	0.05	- 0.94	0.057	0.393
3	Inlet	6	30	-0.20	-0.34	0.655	0.050

[a] Only week 28 to 33 was used for the before period.
[b] Before period △s were non-additive therefore no test was performed.

Table 22. Summary of piping plover observations.

Transect #	Total observations	Transect segment				Habitat Use			Activity			
		East	East-middle	West	West-middle	Intertidal	Beach	Dune	Resting	Feeding	Flying	Breeding
1	10	0	0	3	7	9	1	0	0	10	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	3	0	3	0	0	1	2	0	2	1	0	0
4	26	0	1	14	11	8	12	6	2	13	11	0
5	4	0	0	2	2	4	0	0	0	2	2	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	3	0	0	3	0	0	3	0	2	0	1	0
8	7	0	7	0	0	7	0	0	0	7	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	2	0	0	2	0	2	0	0	0	2	0	0
11	19	16	0	0	3	12	4	3	2	14	3	0
12[a]	5	0	5	0	0	2	3	0	3	2	0	0
13[a]	1	1	0	0	0	0	1	0	1	0	0	0
Totals	80	17	16	24	23	45	26	9	12	51	17	0

[a] Transect at Ocean Isle.

Table 23. Summary of all waterbird data by transect.

Transect#	Island	Site	Total # Species	Total Individuals	Avg. # species/ survey	Avg. # individuals/ kilometer/ survey	Percentage of birds						
							Habitat Use			Activity			
							Intertidal	Beach	Dune	Resting	Feeding	Flying	Breeding
1	Bald Head	Cape Fear	23	10,497	6.91	138.8	79.7	17.8	2.5	10.5	60.7	28.8	0.0
2	Bald Head	South Beach	18	4,519	5.22	68.5	81.8	12.2	5.9	13.3	37.2	49.4	0.1
3	Bald Head	River Cape	23	11,015	7.21	97.1	67.5	25.5	7.0	6.8	61.1	31.7	0.4
4	Oak Island	Caswell	25	7,947	7.66	80.3	91.7	2.9	5.5	6.5	57.0	36.5	0.0
5	Oak Island	East Beach	19	9,131	5.76	138.4	58.1	29.6	12.3	6.2	51.9	41.8	0.1
6	Oak Island	West Beach	14	8,101	4.83	122.8	66.3	17.7	16.0	9.3	46.9	43.8	0.0
7	Oak Island	Lockwoods	22	10,778	7.43	95.0	64.6	20.4	15.0	8.6	42.8	48.6	0.0
8	Holden	Lockwoods	29	8,226	6.60	108.8	78.6	11.7	9.7	9.4	47.5	43.1	0.0
9	Holden	East Beach	20	6,173	5.56	93.6	56.4	25.7	17.9	12.1	38.9	48.9	0.1
10	Holden	West Beach	17	5,003	5.66	75.8	55.4	25.8	18.8	13.9	30.7	55.4	0.0
11	Holden	Shallotte Inlet	31	9,660	8.15	63.9	81.3	9.8	8.9	6.9	48.0	45.1	0.0
12	Ocean Isle	Shallotte Inlet	27	5,888	8.56	86.4	90.1	2.4	7.6	8.7	45.0	46.3	0.0
13	Ocean Isle	East Beach	22	4,807	6.91	90.5	58.3	22.1	19.6	12.6	25.3	62.1	0.0

Table 24. Summary of all shorebird data by transect.

Transect#	Island	Site	Total # Species	Total Individuals	Avg. # species/ survey	Avg. # individuals/ kilometer/ survey	Percentage of birds						
							Habitat Use			Activity			
							Intertidal	Beach	Dune	Resting	Feeding	Flying	Breeding
1	Bald Head	Cape Fear	13	968	2.49	12.8	89.1	9.6	1.3	64.8	12.1	22.5	0.6
2	Bald Head	South Beach	7	351	1.66	5.3	91.2	7.4	1.4	79.8	9.4	10.8	0.0
3	Bald Head	River Cape	13	1,883	3.11	16.6	74.1	23.7	2.1	44.1	50.0	4.7	1.2
4	Oak Island	Caswell	18	3,344	3.93	33.8	81.3	16.4	2.3	25.9	66.1	8.0	0.0
5	Oak Island	East Beach	13	596	2.22	9.0	95.0	4.9	0.2	78.4	14.6	7.1	0.0
6	Oak Island	West Beach	8	708	2.12	10.7	92.4	7.6	0.0	86.9	8.5	4.7	0.0
7	Oak Island	Lockwoods	18	3,616	3.6	31.9	55.7	43.0	1.3	39.1	52.5	8.4	0.0
8	Holden	Lockwoods	16	1,152	2.72	15.2	85.0	13.0	2.0	64.0	13.8	22.1	0.1
9	Holden	East Beach	10	1,070	2.27	16.2	86.4	10.2	3.5	78.8	12.4	8.8	0.0
10	Holden	West Beach	12	1,582	2.71	24.0	73.2	25.5	1.3	62.9	32.1	5.0	0.1
11	Holden	Shallotte Inlet	19	3,886	4.12	25.7	61.8	34.9	3.3	33.5	58.3	7.6	0.5
12	Ocean Isle	Shallotte Inlet	17	1,151	4.28	16.9	83.9	11.6	4.4	33.0	51.3	13.6	2.1
13	Ocean Isle	East Beach	8	564	2.45	10.6	92.0	4.8	3.2	65.3	17.9	16.8	0.0

APPENDICES

APPENDIX A

DESCRIPTIONS OF FEATURES AND COORDINATES ALONG TRANSECTS FOR BRUNSWICK COUNTY, NC BIRD SURVEYS

Appendix A. Descriptions of features and coordinates along transects for Brunswick County, NC bird surveys.

Transect ID[a]	Easting[b]	Northing[b]	Comments/visual aids
TRANSECT #1			
Bald Head - Cape Fear			1 mile long
East end	2315917.115	37794.761	near crossover beach access at the Gazebo
Quarter point	2315799.149	36479.353	near solitary palmetto tree along edge of woods
Mid point	2315540.251	35185.189	On E. beach, in line w/ S. facing dune line and brown house w/ large white brick chimney
Cape Fear	2315502.197	34940.807	"point" of Cape Fear
Three-quarter point	2314612.111	35539.977	approx. 50' W. of clump of large root debris; overturned steps in dunes
West end	2313514.174	36272.671	Beach access at Capt. Charlie's crossover
TRANSECT #2			
Bald Head - South Beach			1 mile long
East end	2310184.548	37794.124	between beach crossovers (one near Killagray Ridge intersection); 2 A-frame w/chimneys
Quarter point	2308955.866	38276.389	vacant lot; house to W. has 2 ship windows; 310' E of beach access w/ life ring
Mid point	2307722.351	38746.510	near intersection of Sea Holly Ct.; 400' E. of house close to beach
Three-quarter point	2306474.703	39177.349	approx. 50 yards W. of large arch window; near tire in dune
West end	2305223.402	39597.850	Beach access at west end of Sandspur Rd.
TRANSECT #3			
Bald Head - West Beach			1.5 miles long
Southeast end	2302167.954	41532.225	Near beige beach rentals (Bald Head Island Villa); just past pond
	2301723.378	41920.273	
	2301233.437	42406.069	
Quarter point	2300893.137	43017.688	near gray "shuttered" house near end of zig-zag sand fence
	2300366.222	44200.784	
Mid point	2300800.229	44743.656	2 story house with catwalk/wind meter; between houses w/ flagpoles; N. end of tern area
	2301206.938	44987.956	
	2301450.946	45230.838	
	2301844.899	45440.544	
Three-quarter point	2302244.298	46036.515	approx. 200' N. of 1st house from 1st beach access (Green Turtle)
Northwest end	2303057.386	47842.365	Entrance to marina; metal pole next to breakwall

Appendix A. (continued)

Transect ID[a]	Easting[b]	Northing[b]	Comments/visual aids
TRANSECT #4			
Oak Island - Ft. Caswell			1.5 miles long
East end	2298161.812	54812.636	Last small house near end of breakwall; 3rd house N. of pier
	2298546.071	54674.907	
	2299134.678	53839.525	
Quarter point	2299346.409	53331.501	100 yards S. of large building along beach
	2299359.942	52895.648	
	2298978.014	51831.457	
Mid point	2298722.168	51507.045	In line with Old Baldy and tower on Assembly grounds; green buoy with house left of baldy
	2298308.477	51308.120	
	2297719.000	51280.710	
	2297232.524	51409.947	
Three-quarter point	2296852.943	51607.953	1980'from walkover; yuccas on ridge; log on high beach
West end	2295032.611	52388.352	Beach access at Assembly grounds guard gate
TRANSECT #5			
Oak Island - Middle East			1 mile long
East end	2278588.057	57260.419	Yaupon pier
Quarter point	2277329.469	57656.341	Peach house, 40' east of SE 79th st.
Mid point	2276028.260	57907.216	Green house, among group of four houses, with long walkway, satellite dish
Three-quarter point	2274742.483	58205.352	Between new house and beige house; 150' east of Beach st. and W. of gazebo
West end	2273444.058	58470.762	House with long walkway over marsh; 200' W. of 67th st.; 200' W. of beach access
TRANSECT #6			
Oak Island - Middle West			1 mile long
East end	2258839.339	60500.678	Ocean crest pier
Quarter point	2257528.304	60642.796	House #921; lt. green house w/asbestos siding, pelican in window
Mid point	2256208.705	60731.652	House # 601 w/2 solar panels, next to "Baker's Dozen"
Three-quarter point	2254889.443	60793.157	House #113 "Abbey Rd"; gray shingles, 2 story, across from Elk's lodge
West end	2253569.125	60828.156	Near W. 2nd Place beach access; next to gray house "Camp David CSA"
TRANSECT #7			
Oak Island - Lockwoods Folly			1.5 miles long
East end	2238581.724	60408.552	At 57th Place beach access

Appendix A. (continued)

Transect ID[a]	Easting[b]	Northing[b]	Comments/visual aids
Quarter point	2236609.499	60231.081	2nd house past lt. green house (2 story) w/ fish eye window in widow's peak
Mid point	2234648.298	59946.335	Last house on main road prior to parking lot; low 2 story w/ green top/white bottom
	2233704.061	59880.751	
Three-quarter point	2232749.937	60280.810	Between red buoy and last house (2 story)
	2232017.843	60702.416	
	2231850.942	61412.911	
	2232037.702	61500.375	
West end	2232013.673	61302.189	Past pole w/2 stripes near tip of cove
TRANSECT #8			
Holden Beach - Lockwoods Folly			1 mile long
East end	2231489.606	62508.131	Near red buoy; almost to back side of E. end of island
	2231371.256	61965.429	
Quarter point	2230848.562	61392.921	Between last house and gazebo
Mid point	2229586.288	61008.077	Near end of zig-zag sand fence; near W. gazebo; house w/ 3 A-peaks w/ arch window
Three-quarter point	2228297.130	60723.601	Between houses "Sand Dollars" and green cottage w/ red doors
West end	2226979.483	60648.555	Beach access at Ave. B
TRANSECT #9			
Holden Beach - Middle East			1 mile long
East end	2224420.252	60572.629	Beach access at ferry landing road
Quarter point	2223107.222	60439.645	House #124 (low brown cottage); near CAMA beach access
Mid point	2221798.748	60265.456	At reality, "keep-off dunes $500 fine" sign; across from flag poles; near tower, bridge
Three-quarter point	2220484.007	60146.756	Beige 2 story w/ #1730 to W. and low green 1 story to E.
West end	2219173.051	59993.551	Beige split 2 story (#224 East House); 2 houses W. #221
TRANSECT #10			
Holden Beach - Middle West			1 mile long
East end	2205356.469	58424.860	House #767 (Adventure 3); E. of "keep off dunes" sign; 2 houses W. of "Great Place"
Quarter point	2204047.035	58249.901	Low yellow house (#823); W. of #821(low, vinyl house) on access steps
Mid point	2202739.038	58063.095	House # 875 (twin peak, A-frame, clapboard) across from Swordfish Dr.
Three-quarter point	2201433.066	57863.895	Low house with 3 palm trees; near pole in beach

Appendix A. (concluded)

Transect ID[a]	Easting[b]	Northing[b]	Comments/visual aids
West end	2200127.632	57661.255	House #981 (Bumble's Beach Cottage); 2 houses W. of red-shingled #977
TRANSECT #11			
Holden Beach - Shallotte Inlet			approximately 1.75 miles long
East end	2194460.587	56335.493	Beach crossing at Skimmer Ct.
Quarter point	2191903.624	55674.388	Double peach beach house w/ connecting breezeway
Mid point	2189304.121	56140.466	210' E. of new observation deck; due N. of red buoy #8
	2188404.891	56380.762	
	2187709.025	56817.187	
Three-quarter point	2187504.156	57683.904	In line w/ green and red buoys near inlet
	2187501.455	58194.300	
West end	2188025.854	58431.324	East side of small creek on back-side of island

[a]Transects were established between 30 November and 1 December 2000 with a Trimble Pro XRS GPS unit.
Transects were divided into four sections and identified in the field with red "pin flags" on the dune.
Each of the four segments for each transect are referred to as east, east-middle, west-middle, and west on the data form.
Unlabeled coordinates represent intermediate points established (but not identified in the field) to reflect a change in direction along the transect
[b]Coordinates are reported in North Carolina State Plane NAD 83 (feet).

APPENDIX B

SUMMARY OF SURVEY DATES OF ALL TRANSECTS

Appendix B. Summary of survey dates of all transects.

Week #	Transect #										
	1	2	3	4	5	6	7	8	9	10	11
1	19 DEC. 00	19 DEC. 00	19 DEC. 00	15 DEC. 00	15 DEC. 00	15 DEC. 00	15 DEC. 00	16 DEC. 00	16 DEC. 00	16 DEC. 00	16 DEC. 00
2	31 DEC. 00	31 DEC. 00	31 DEC. 00	27 DEC. 00	27 DEC. 00	27 DEC. 00	27 DEC. 00	26 DEC. 00	26 DEC. 00	26 DEC. 00	26 DEC. 00
3	11 JAN. 01	11 JAN. 01	11 JAN. 01	10 JAN. 01	10 JAN. 01	10 JAN. 01	10 JAN. 01	13 JAN. 01	13 JAN. 01	13 JAN. 01	13 JAN. 01
4	24 JAN. 01	24 JAN. 01	24 JAN. 01	25 JAN. 01	25 JAN. 01	25 JAN. 01	25 JAN. 01	27 JAN. 01	27 JAN. 01	27 JAN. 01	27 JAN. 01
5	07 FEB. 01	07 FEB. 01	07 FEB. 01	08 FEB. 01	08 FEB. 01	8 FEB. 01	8 FEB. 01	10 FEB. 01	10 FEB. 01	10 FEB. 01	10 FEB. 01
6	17 FEB. 01	17 FEB. 01	17 FEB. 01	13 FEB. 01	13 FEB. 01	13 FEB. 01	13 FEB. 01	15 FEB. 01	15 FEB. 01	15 FEB. 01	15 FEB. 01
7	24 FEB. 01	24 FEB. 01	24 FEB. 01	20 FEB. 01	20 FEB. 01	20 FEB. 01	20 FEB. 01	23 FEB. 01	23 FEB. 01	23 FEB. 01	23 FEB. 01
8	27 FEB. 01	27 FEB. 01	27 FEB. 01	26 FEB. 01	26 FEB. 01	26 FEB. 01	26 FEB. 01	03 MAR. 01	03 MAR. 01	03 MAR. 01	03 MAR. 01
9	10 MAR. 01	10 MAR. 01	10 MAR. 01	07 MAR. 01	07 MAR. 01	07 MAR. 01	07 MAR. 01	08 MAR. 01	08 MAR. 01	08 MAR. 01	08 MAR. 01
10	17 MAR. 01	17 MAR. 01	17 MAR. 01	13 MAR. 01	13 MAR. 01	13 MAR. 01	13 MAR. 01	14 MAR. 01	14 MAR. 01	14 MAR. 01	14 MAR. 01
11	22 MAR. 01	22 MAR. 01	22 MAR. 01	19 MAR. 01	19 MAR. 01	19 MAR. 01	19 MAR. 01	24 MAR. 01	24 MAR. 01	24 MAR. 01	24 MAR. 01
12	27 MAR. 01	27 MAR. 01	27 MAR. 01	28 MAR. 01	28 MAR. 01	28 MAR. 01	28 MAR. 01	31 MAR. 01	31 MAR. 01	31 MAR. 01	31 MAR. 01
13	07 APR. 01	07 APR. 01	07 APR. 01	06 APR. 01	06 APR. 01	06 APR. 01	06 APR. 01	04 APR. 01	04 APR. 01	04 APR. 01	04 APR. 01
14	11 APR. 01	11 APR. 01	11 APR. 01	14 APR. 01	14 APR. 01	14 APR. 01	14 APR. 01	10 APR. 01	10 APR. 01	10 APR. 01	10 APR. 01
15	17 APR. 01	17 APR. 01	17 APR. 01	19 APR. 01	19 APR. 01	19 APR. 01	19 APR. 01	16 APR. 01	16 APR. 01	16 APR. 01	16 APR. 01
16	23 APR. 01	23 APR. 01	23 APR. 01	26 APR. 01	26 APR. 01	26 APR. 01	26 APR. 01	24 APR. 01	24 APR. 01	24 APR. 01	24 APR. 01
17	03 MAY. 01	03 MAY. 01	03 MAY. 01	01 MAY. 01	01 MAY. 01	01 MAY. 01	01 MAY. 01	02 MAY. 01	02 MAY. 01	09 MAY. 01	09 MAY. 01
18	12 MAY. 01	12 MAY. 01	12 MAY. 01	08 MAY. 01	08 MAY. 01	08 MAY. 01	08 MAY. 01	09 MAY. 01	09 MAY. 01	09 MAY. 01	09 MAY. 01
19	19 MAY. 01	19 MAY. 01	19 MAY. 01	15 MAY. 01	15 MAY. 01	15 MAY. 01	15 MAY. 01	16 MAY. 01	16 MAY. 01	16 MAY. 01	16 MAY. 01
20	26 MAY. 01	26 MAY. 01	26 MAY. 01	23 MAY. 01	23 MAY. 01	23 MAY. 01	23 MAY. 01	24 MAY. 01	24 MAY. 01	24 MAY. 01	24 MAY. 01
21	02 JUN. 01	02 JUN. 01	02 JUN. 01	28 MAY. 01	28 MAY. 01	28 MAY. 01	28 MAY. 01	01 JUN. 01	01 JUN. 01	01 JUN. 01	01 JUN. 01
22	06 JUN. 01		06 JUN. 01				10 JUN. 01	05 JUN. 01			05 JUN. 01
23	15 JUN. 01		15 JUN. 01				17 JUN. 01	16 JUN. 01			16 JUN. 01
24	19 JUN. 01		19 JUN. 01				24 JUN. 01	23 JUN. 01			23 JUN. 01
25	25 JUN. 01		25 JUN. 01				29 JUN. 01	30 JUN. 01			30 JUN. 01
26	02 JUL. 01		02 JUL. 01				04 JUL. 01	03 JUL. 01			03 JUL. 01
27	10 JUL. 01		10 JUL. 01				11 JUL. 01	12 JUL. 01			12 JUL. 01
28	21 JUL. 01	21 JUL. 01	21 JUL. 01	17 JUL. 01	17 JUL. 01	17 JUL. 01	17 JUL. 01	20 JUL. 01	20 JUL. 01	20 JUL. 01	20 JUL. 01
29	28 JUL. 01	28 JUL. 01	28 JUL. 01	25 JUL. 01	25 JUL. 01	25 JUL. 01	25 JUL. 01	27 JUL. 01	27 JUL. 01	27 JUL. 01	27 JUL. 01
30	04 AUG. 01	04 AUG. 01	04 AUG. 01	01 AUG. 01	01 AUG. 01	01 AUG. 01	01 AUG. 01	03 AUG. 01	03 AUG. 01	03 AUG. 01	03 AUG. 01
31	10 AUG. 01	10 AUG. 01	10 AUG. 01	07 AUG. 01	07 AUG. 01	07 AUG. 01	07 AUG. 01	08 AUG. 01	08 AUG. 01	08 AUG. 01	08 AUG. 01
32	16 AUG. 01	16 AUG. 01	16 AUG. 01	15 AUG. 01	15 AUG. 01	15 AUG. 01	15 AUG. 01	14 AUG. 01	14 AUG. 01	14 AUG. 01	14 AUG. 01
33	20 AUG. 01	20 AUG. 01	20 AUG. 01	21 AUG. 01	21 AUG. 01	21 AUG. 01	21 AUG. 01	22 AUG. 01	22 AUG. 01	22 AUG. 01	22 AUG. 01
34	28 AUG. 01	28 AUG. 01	28 AUG. 01	29 AUG. 01	29 AUG. 01	29 AUG. 01	29 AUG. 01	30 AUG. 01	30 AUG. 01	30 AUG. 01	30 AUG. 01
35	07 SEP. 01	07 SEP. 01	07 SEP. 01	04 SEP. 01	04 SEP. 01	04 SEP. 01	04 SEP. 01	05 SEP. 01	05 SEP. 01	05 SEP. 01	05 SEP. 01
36	12 SEP. 01	12 SEP. 01	12 SEP. 01	11 SEP. 01	11 SEP. 01	11 SEP. 01	11 SEP. 01	13 SEP. 01	13 SEP. 01	13 SEP. 01	13 SEP. 01
37	18 SEP. 01	18 SEP. 01	18 SEP. 01	19 SEP. 01	19 SEP. 01	19 SEP. 01	19 SEP. 01	20 SEP. 01	20 SEP. 01	20 SEP. 01	20 SEP. 01
38	26 SEP. 01	26 SEP. 01	26 SEP. 01	25 SEP. 01	25 SEP. 01	25 SEP. 01	25 SEP. 01	27 SEP. 01	27 SEP. 01	27 SEP. 01	27 SEP. 01
39	01 OCT. 01	01 OCT. 01	01 OCT. 01	04 OCT. 01	04 OCT. 01	04 OCT. 01	04 OCT. 01	02 OCT. 01	02 OCT. 01	02 OCT. 01	02 OCT. 01
40	10 OCT. 01	10 OCT. 01	10 OCT. 01	11 OCT. 01	11 OCT. 01	11 OCT. 01	11 OCT. 01	12 OCT. 01	12 OCT. 01	12 OCT. 01	12 OCT. 01

Appendix B. (concluded)

Week #	Transect #										
	1	2	3	4	5	6	7	8	9	10	11
41	15 OCT. 01	15 OCT. 01	15 OCT. 01	16 OCT. 01	16 OCT. 01	16 OCT. 01	16 OCT. 01	18 OCT. 01	18 OCT. 01	18 OCT. 01	18 OCT. 01
42	22 OCT. 01	22 OCT. 01	22 OCT. 01	25 OCT. 01	25 OCT. 01	25 OCT. 01	25 OCT. 01	26 OCT. 01	26 OCT. 01	26 OCT. 01	26 OCT. 01
43	30 OCT. 01	30 OCT. 01	30 OCT. 01	31 OCT. 01	31 OCT. 01	31 OCT. 01	31 OCT. 01	02 NOV. 01	02 NOV. 01	02 NOV. 01	02 NOV. 01
44	05 NOV. 01	05 NOV. 01	05 NOV. 01	07 NOV. 01	07 NOV. 01	07 NOV. 01	07 NOV. 01	08 NOV. 01	08 NOV. 01	08 NOV. 01	08 NOV. 01
45	12 NOV. 01	12 NOV. 01	12 NOV. 01	14 NOV. 01	14 NOV. 01	14 NOV. 01	14 NOV. 01	15 NOV. 01	15 NOV. 01	15 NOV. 01	15 NOV. 01
46	19 NOV. 01	19 NOV. 01	19 NOV. 01	20 NOV. 01	20 NOV. 01	20 NOV. 01	20 NOV. 01	21 NOV. 01	21 NOV. 01	21 NOV. 01	21 NOV. 01
47	27 NOV. 01	27 NOV. 01	27 NOV. 01	28 NOV. 01	28 NOV. 01	28 NOV. 01	28 NOV. 01	29 NOV. 01	29 NOV. 01	29 NOV. 01	29 NOV. 01

APPENDIX C

COMPLETED DATA SURVEY FORMS
(December 2000 through November 2001)

APPENDIX D

TOTAL NUMBER OF WATERBIRD SPECIES DURING EACH SURVEY BY TRANSECT

Appendix D. Total number of waterbird species during each survey by transect.

Week#	Transect #										
	1	2	3	4	5	6	7	8	9	10	11
1	7	3	5	3	4	5	6	3	4	5	5
2	4	4	6	7	3	4	6	7	5	3	5
3	5	2	5	6	3	2	4	3	1	2	4
4	5	4	7	8	3	2	3	2	4	3	5
5	4	3	6	8	5	3	4	3	3	3	6
6	5	6	4	7	3	2	4	3	4	4	6
7	4	3	7	4	6	3	5	3	4	3	7
8	7	2	8	6	3	1	3	6	3	5	9
9	3	4	9	5	4	4	8	6	6	8	7
10	5	6	7	9	6	4	5	6	7	5	6
11	6	6	7	3	6	5	7	7	6	6	6
12	9	6	9	8	7	6	10	8	8	7	9
13	10	5	10	11	5	5	7	12	10	8	12
14	8	7	12	10	8	7	11	9	8	7	11
15	9	9	10	10	7	6	9	10	6	5	8
16	8	6	4	12	8	5	10	10	5	8	11
17	9	4	6	12	5	4	7	6	5	5	6
18	8	2	8	8	6	4	7	8	5	7	9
19	4	5	9	9	4	5	7	9	4	5	9
20	4	4	7	7	4	6	9	6	5	3	6
21	5	5	5	4	6	4	6	6	5	5	9
22	5	—	7	—	—	—	4	4	—	—	7
23	4	—	5	—	—	—	7	7	—	—	8
24	3	—	6	—	—	—	6	5	—	—	6
25	7	—	7	—	—	—	8	5	—	—	6
26	6	—	6	—	—	—	9	7	—	—	8
27	8	—	10	—	—	—	8	10	—	—	12
28	6	6	6	7	5	2	5	7	7	6	7
29	8	4	8	8	5	3	6	6	6	6	6

Appendix D. (concluded)

Week#	Transect #										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
30	6	5	8	7	4	4	10	8	5	6	8
31	8	3	7	8	6	4	9	6	4	4	5
32	7	3	5	9	5	3	9	6	6	3	4
33	13	8	13	8	4	5	8	6	6	6	9
34	8	6	9	7	4	6	8	9	6	5	11
35	6	6	9	10	7	6	9	10	5	6	10
36	5	6	8	10	6	7	8	7	6	6	8
37	8	5	10	10	9	4	9	9	4	6	9
38	8	7	5	7	7	6	9	5	8	7	15
39	6	4	7	9	7	7	8	10	5	8	10
40	6	5	7	4	5	5	11	6	4	8	12
41	6	7	6	11	7	7	8	8	7	6	9
42	10	6	6	5	9	8	10	6	8	5	11
43	10	8	6	8	8	7	10	5	8	8	8
44	8	6	5	6	7	6	9	5	6	7	12
45	9	9	6	10	8	6	7	9	7	8	9
46	11	8	9	6	9	7	8	7	5	6	8
47	14	6	7	7	7	7	7	6	7	7	11
Total	325	214	339	314	235	197	348	312	228	231	385
Average species/ survey	6.9	5.2	7.2	7.7	5.7	4.8	7.4	6.6	5.6	5.6	8.2

"—" = no survey

APPENDIX E

TOTAL NUMBER OF WATERBIRD INDIVIDUALS DURING EACH SURVEY BY TRANSECT

Appendix E. Total number of waterbird individuals during each survey by transect.

Week#	Transect #										
	1	2	3	4	5	6	7	8	9	10	11
1	315	23	70	78	149	327	136	19	71	81	50
2	239	46	105	467	257	151	95	645	59	22	26
3	348	4	318	305	380	302	83	181	71	58	178
4	296	67	95	238	276	174	64	71	137	79	107
5	30	12	84	1352	202	210	90	56	59	23	64
6	17	15	62	705	308	209	111	37	117	41	36
7	15	16	268	19	232	110	50	47	165	43	192
8	64	14	689	109	217	90	65	25	75	28	167
9	10	22	478	12	222	194	257	70	134	183	32
10	25	56	381	178	141	183	41	80	182	151	122
11	33	28	243	235	206	182	212	316	90	92	78
12	27	725	85	519	160	205	48	104	84	36	141
13	538	20	70	62	140	189	87	136	135	113	401
14	450	30	350	210	96	230	462	73	345	85	53
15	121	121	511	170	195	141	215	138	74	218	200
16	491	17	31	114	126	118	71	139	225	213	116
17	440	16	184	80	265	160	82	56	127	153	37
18	276	30	177	73	165	73	99	140	206	168	183
19	41	110	74	135	135	153	123	59	171	241	77
20	126	211	149	33	111	185	132	133	186	114	70
21	34	214	65	74	117	99	116	192	189	130	195
22	125	—	49	—	—	—	52	118	—	—	81
23	35	—	98	—	—	—	93	151	—	—	99
24	109	—	149	—	—	—	135	118	—	—	181
25	228	—	150	—	—	—	228	116	—	—	150
26	208	—	778	—	—	—	171	195	—	—	273
27	142	—	407	—	—	—	274	961	—	—	235
28	50	58	812	229	123	226	151	118	76	152	121
29	104	64	301	223	193	170	198	105	123	80	79

Appendix E. (concluded)

Week#	Transect #										
	1	2	3	4	5	6	7	8	9	10	11
30	100	66	429	122	118	124	232	76	41	79	87
31	167	10	708	141	165	61	66	173	91	81	187
32	41	15	46	91	29	41	424	127	102	47	49
33	389	126	281	68	60	102	67	88	276	106	137
34	194	42	344	65	59	108	135	88	122	88	311
35	121	56	652	299	154	169	348	291	64	115	247
36	50	47	39	95	122	250	462	107	282	128	75
37	221	27	389	77	61	64	1071	752	440	283	412
38	784	83	49	76	55	41	284	43	90	122	641
39	58	341	22	69	54	66	162	493	77	113	196
40	56	152	186	63	36	97	672	101	198	144	595
41	82	58	73	327	76	155	263	102	187	79	580
42	1537	350	100	54	1073	281	275	182	132	65	176
43	734	280	82	182	308	235	200	66	144	135	305
44	273	316	53	151	234	715	1043	71	205	176	419
45	388	374	90	248	1632	588	367	661	245	210	980
46	313	226	158	54	357	282	612	67	147	166	262
47	52	31	81	145	122	641	154	139	229	362	257
total	10497	4519	11015	7947	9131	8101	10778	8226	6173	5003	9660
Average birds/ survey	223.3	110.2	234.4	193.8	222.7	197.6	229.3	175.0	150.6	122.0	205.5

"—" = no surveys

APPENDIX F

TOTAL NUMBER OF SHOREBIRD SPECIES DURING EACH SURVEY BY TRANSECT

Appendix F. Total number of shorebird species during each survey by transect.

Week#	Transect #										
	1	2	3	4	5	6	7	8	9	10	11
1	1	2	1	5	3	1	3	2	1	1	3
2	1	1	4	4	1	0	3	5	3	1	2
3	2	1	1	6	1	1	2	1	1	0	7
4	2	0	4	2	0	0	3	2	1	1	3
5	2	3	2	5	1	1	0	2	1	1	4
6	1	1	2	5	0	0	3	2	0	2	2
7	0	1	1	0	2	0	1	1	2	4	3
8	2	1	3	2	1	0	0	2	0	1	2
9	1	2	2	1	0	0	6	1	0	1	6
10	2	1	2	4	0	0	3	3	0	2	1
11	3	1	6	3	0	3	3	2	0	0	4
12	4	1	3	6	1	1	2	0	0	1	7
13	1	1	2	1	4	1	3	0	2	3	10
14	2	1	5	2	0	1	3	3	0	0	2
15	2	2	3	4	2	3	3	1	1	2	3
16	3	3	4	6	2	2	4	1	2	3	4
17	4	1	5	7	1	2	5	2	2	2	10
18	2	2	3	5	3	3	1	3	4	5	4
19	4	5	3	5	5	6	6	6	3	4	12
20	2	2	3	3	4	1	5	3	5	2	3
21	3	1	2	4	1	2	3	2	3	2	4
22	2	—	1	—	—	—	1	2	—	—	3
23	3	—	2	—	—	—	1	1	—	—	4
24	2	—	4	—	—	—	1	1	—	—	2
25	4	—	1	—	—	—	2	1	—	—	1
26	3	—	1	—	—	—	4	1	—	—	2
27	2	—	2	—	—	—	3	2	—	—	2
28	3	1	2	3	3	1	5	5	1	4	3
29	7	1	2	3	2	1	4	3	2	3	5

Appendix F. (concluded)

Week#	Transect #										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
30	4	1	6	2	2	2	4	7	3	2	2
31	5	1	2	4	2	3	3	3	2	2	2
32	4	2	4	5	4	3	11	4	5	3	3
33	4	2	7	2	4	3	3	4	3	3	10
34	3	1	2	2	3	3	3	6	3	3	2
35	2	1	4	6	6	5	7	5	3	4	9
36	2	2	3	3	6	3	2	2	3	3	3
37	4	2	4	6	2	1	6	4	3	4	1
38	2	2	4	2	3	2	5	3	4	4	4
39	2	2	4	5	2	4	5	3	3	4	2
40	1	2	5	1	3	2	4	2	2	5	5
41	2	2	5	6	3	5	4	5	4	4	4
42	2	2	2	2	1	4	6	3	4	4	4
43	2	3	3	8	2	3	3	3	4	4	3
44	3	2	4	6	5	5	8	3	4	4	6
45	2	2	3	7	2	3	2	3	6	5	5
46	2	3	4	7	1	4	8	5	2	5	7
47	2	1	4	1	3	2	2	4	1	4	3
total	118	68	146	161	91	87	169	129	93	112	193
Average birds/ survey	2.5	1.7	3.1	3.9	2.2	2.1	3.6	2.7	2.3	2.7	4.1

"—" = no survey

APPENDIX G

TOTAL NUMBER OF SHOREBIRD INDIVIDUALS DURING EACH SURVEY BY TRANSECT

Appendix G. Total number of shorebird individuals during each survey by transect.

Week#	Transect #										
	1	2	3	4	5	6	7	8	9	10	11
1	1	3	11	121	65	1	15	2	2	8	14
2	3	4	14	18	1	0	13	87	6	1	36
3	4	3	3	173	2	5	3	41	9	0	189
4	5	0	7	23	0	0	28	8	41	2	10
5	4	5	3	81	1	1	0	73	1	11	13
6	1	4	6	80	0	0	5	3	0	5	8
7	0	1	4	0	11	0	1	3	3	214	3
8	8	1	9	39	4	0	0	3	0	1	3
9	3	2	2	2	0	0	496	1	0	4	40
10	3	2	6	25	0	0	5	50	0	4	1
11	6	1	68	16	0	4	37	4	0	0	10
12	16	3	6	229	4	5	8	0	0	1	132
13	3	2	6	5	20	2	14	0	34	16	737
14	15	2	137	28	0	1	194	59	0	0	2
15	8	4	44	98	12	14	492	2	12	98	21
16	7	6	10	177	10	15	33	5	13	57	11
17	42	2	164	182	3	24	124	2	13	10	605
18	13	10	51	27	43	8	13	32	14	46	32
19	16	68	13	137	28	30	145	114	35	69	488
20	15	21	16	9	25	10	80	32	59	13	75
21	16	1	2	23	10	13	22	15	71	15	19
22	7	—	1	—	—	—	1	3	—	—	4
23	4	—	6	—	—	—	1	1	—	—	8
24	3	—	19	—	—	—	8	1	—	—	8
25	12	—	1	—	—	—	24	2	—	—	10
26	8	—	6	—	—	—	30	9	—	—	6
27	17	—	8	—	—	—	6	8	—	—	10
28	20	2	25	16	8	8	16	68	8	19	51
29	197	8	42	56	9	3	58	11	50	69	57

Appendix G. (concluded)

Week#	Transect #										
	1	2	3	4	5	6	7	8	9	10	11
30	38	8	68	28	33	40	61	30	49	28	29
31	37	7	75	42	33	47	45	54	51	36	27
32	31	6	20	14	37	36	154	38	56	39	32
33	84	69	107	3	36	48	24	63	65	48	322
34	13	2	18	8	11	43	37	34	36	33	6
35	10	1	101	63	32	50	91	37	32	43	258
36	12	8	43	6	27	30	29	15	21	42	28
37	39	4	170	217	7	5	121	27	21	51	47
38	30	9	31	6	24	9	79	14	30	113	26
39	21	8	44	69	10	33	31	29	55	71	38
40	20	12	308	4	10	25	85	10	32	47	59
41	8	10	90	90	6	46	32	42	73	131	26
42	45	18	17	7	3	23	119	21	37	18	32
43	14	11	12	240	13	48	32	20	43	32	40
44	69	4	21	143	24	33	397	12	35	46	111
45	8	10	23	463	12	27	7	29	43	53	76
46	23	6	22	372	1	12	388	20	12	54	99
47	9	3	23	4	21	9	12	18	8	34	27
total	968	351	1883	3344	596	708	3616	1152	1070	1582	3886
Average birds/ survey	20.6	8.6	40.1	81.6	14.5	17.3	76.9	24.5	26.1	38.6	82.7

"—" = no surveys

APPENDIX H

SUMMARY NOTES ON NESTING CHRONOLOGY OF BREEDING OR SUSPECTED BREEDING BIRDS ALONG TRANSECTS 1 THROUGH 11, BRUNSWICK COUNTY, NC

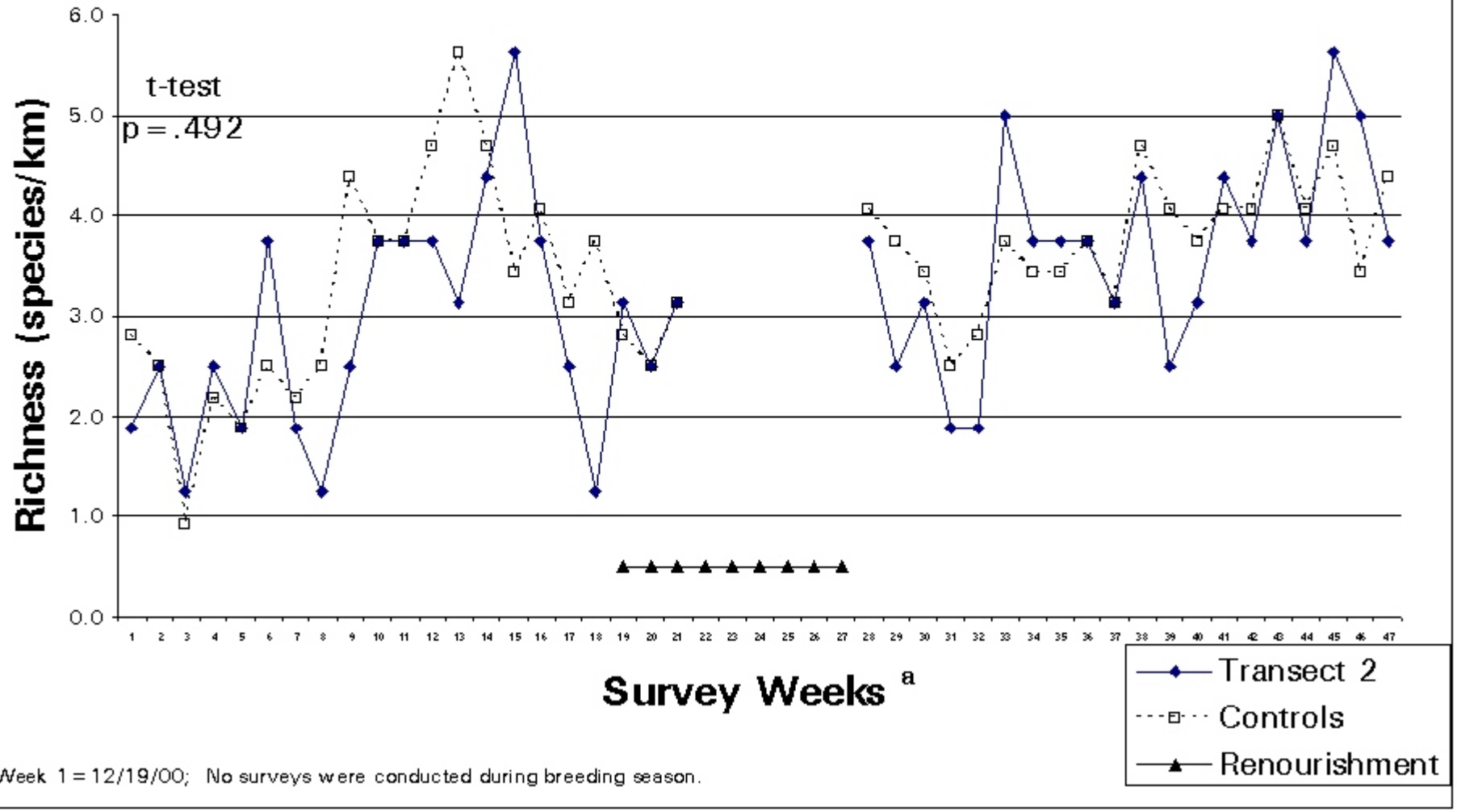
Appendix H. Summary notes on nesting chronology of breeding or suspected breeding birds along Transects 1 through 11, Brunswick County, NC.

Species	Island	Transect	Date	Courtship/displays	Eggs/nests	Young
Wilson's Plover	Bald Head	1 W	15-Jun-01		Nest with 3 eggs	
		1 W	19-Jun-01		Nest with 3 eggs	
		1 W	25-Jun-01		Nest with 3 eggs, female on nest	
		1 E-M	10-Jul-01			Young spotted with adult male
		1 E-M	21-Jul-01			Fledgling suspected hiding in dunes, adult female present
		1 W	28-Jul-01			2 young with adult, feeding in dunes
Wilson's Plover	Bald Head	3 E-M	19-May-01	Pair in dunes		
		3 E-M	26-May-01	Pair in dunes		
		3 E-M	2-Jun-01	Pair in dunes		
		3 E-M	15-Jun-01	Pair w/2 young		2 young (unable to fly)
		3 E-M	19-Jun-01	Pair in dunes		
		3 E-M	10-Jul-01	Female feigning broken wing		
Wilson's Plover	Oak Island	7 W	4-Jul-01			Chick (< 1 week) spotted with 2 adults in beach area
		7 W	11-Jul-01			Flightless young spotted with male in dune area
		7 W	17-Jul-01			Chick feeding with adult in dune area
		7 W	25-Jul-01	Adult feeding in dunes		
Wilson's Plover	Holden Beach	8 E	1-Jun-01	Female feigning broken wing		
Wilson's Plover	Holden Beach	11 W-M	16-Apr-01	Pair in dunes		
		11 W-M	2-May-01	Pair in dunes		
		11 W	9-May-01	Pair in dunes		
		11 W	16-May-01	Adult in dunes		
		11 W-M	1-Jun-01	Adult in dunes		
		11 W-M	5-Jun-01		Possible nest suspected in dunes, adult seen nearby	
		11 W-M	16-Jun-01			Immature bird seen traveling through dunes
		11 W-M	23-Jun-01		Adult male resting in dune area	
Least Tern	Bald Head	3 E-M	12-May-01	Pair in Least tern area		
		3 E-M	19-May-01	Pair in Least tern area		
		3 E-M	26-May-01	Six birds in Least tern area		
		3 E-M	2-Jun-01	Four birds in Least tern area		
		3 E-M	6-Jun-01	Six birds in Least tern area	Nest (#1) with 3 eggs	
		3 E-M	15-Jun-01	Five birds in Least tern area	Nest (#1) with 1 egg and 2 chicks, Nest (#2) with 2 eggs	
		3 E-M	19-Jun-01	Four birds breeding in Least tern area	Nest (#1) was empty, nest (#2) with 2 eggs	
		3 E-M	25-Jun-01	Five birds breeding in Least tern area	Nest (#2) with 2 eggs	
		3 E-M	2-Jul-01	Four birds breeding in Least tern area	Nest (#2) with 1 egg	
		3 E-M	10-Jul-01	Six birds breeding in Least tern area		
Willet	Holden Beach	11 E-M	1-Jun-01	Pair was suspected breeding along marsh edge behind island		
		11 E	5-Jun-01	Pair was suspected breeding along marsh edge behind island		
		11 E	23-Jun-01	Adults seen on several occasions from 22-Jun-01 through 27-Jul-01		
Willet	Holden Beach	11 W	24-Apr-01	Two pairs were suspected breeding along marsh edge behind island		
		11 W	5-May-01	Several birds were seen on many occasions from 5-May-01 through 27-Jul-01		

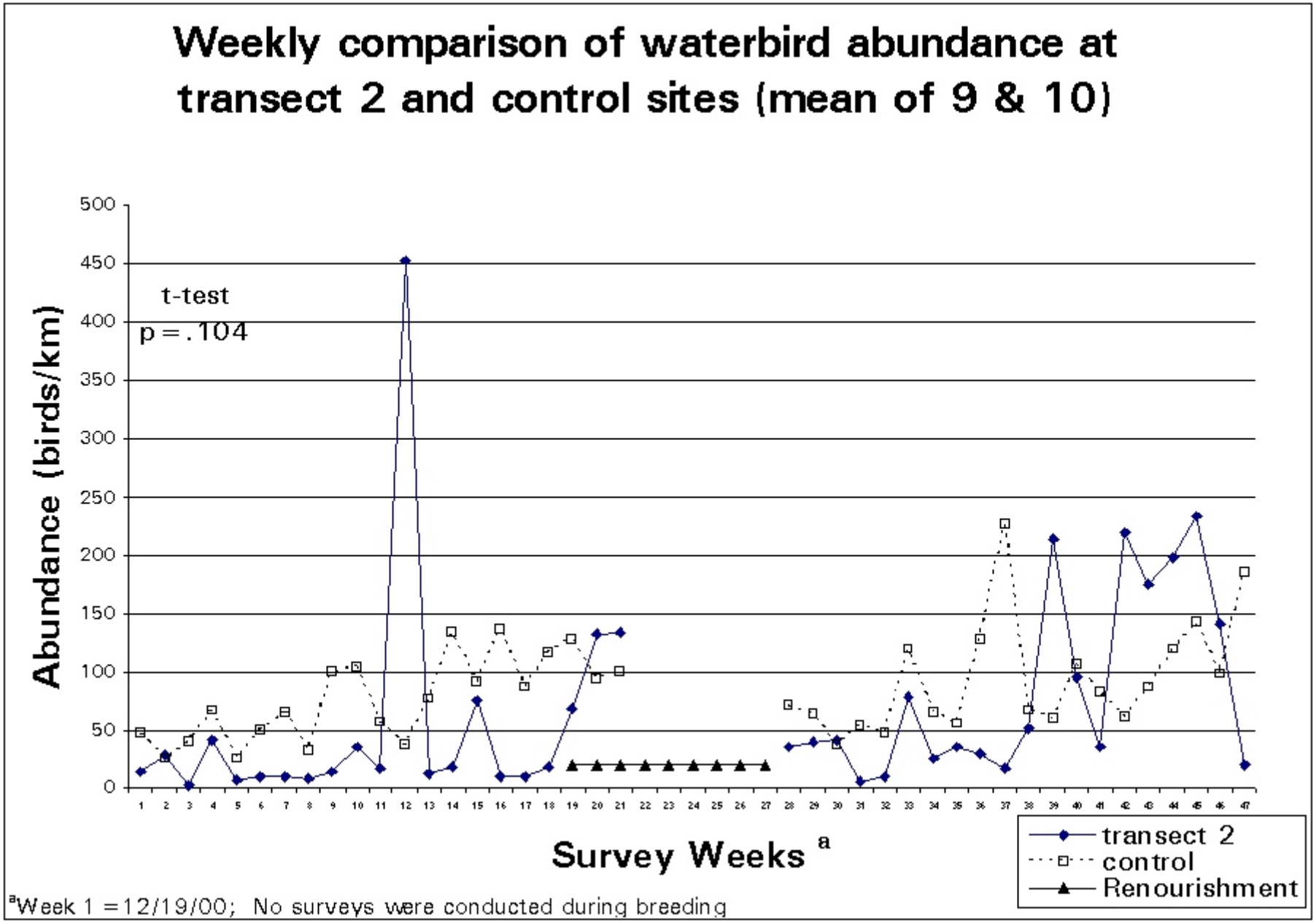
APPENDIX I

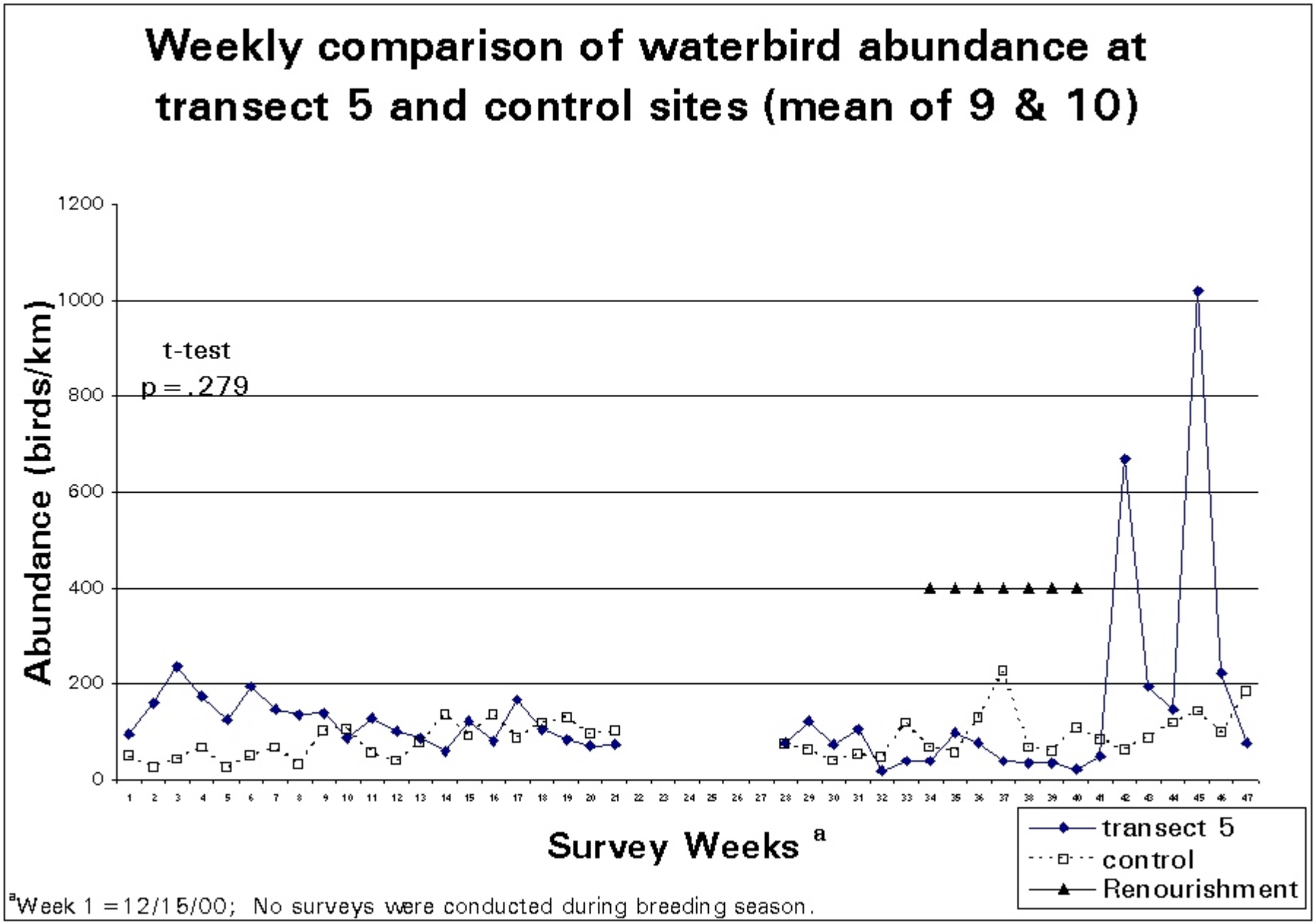
FIGURES DEPICTING WEEKLY WATERBIRD RICHNESS AND ABUNDANCE AT RENOURISHED TRANSECTS AND CONTROL AREAS

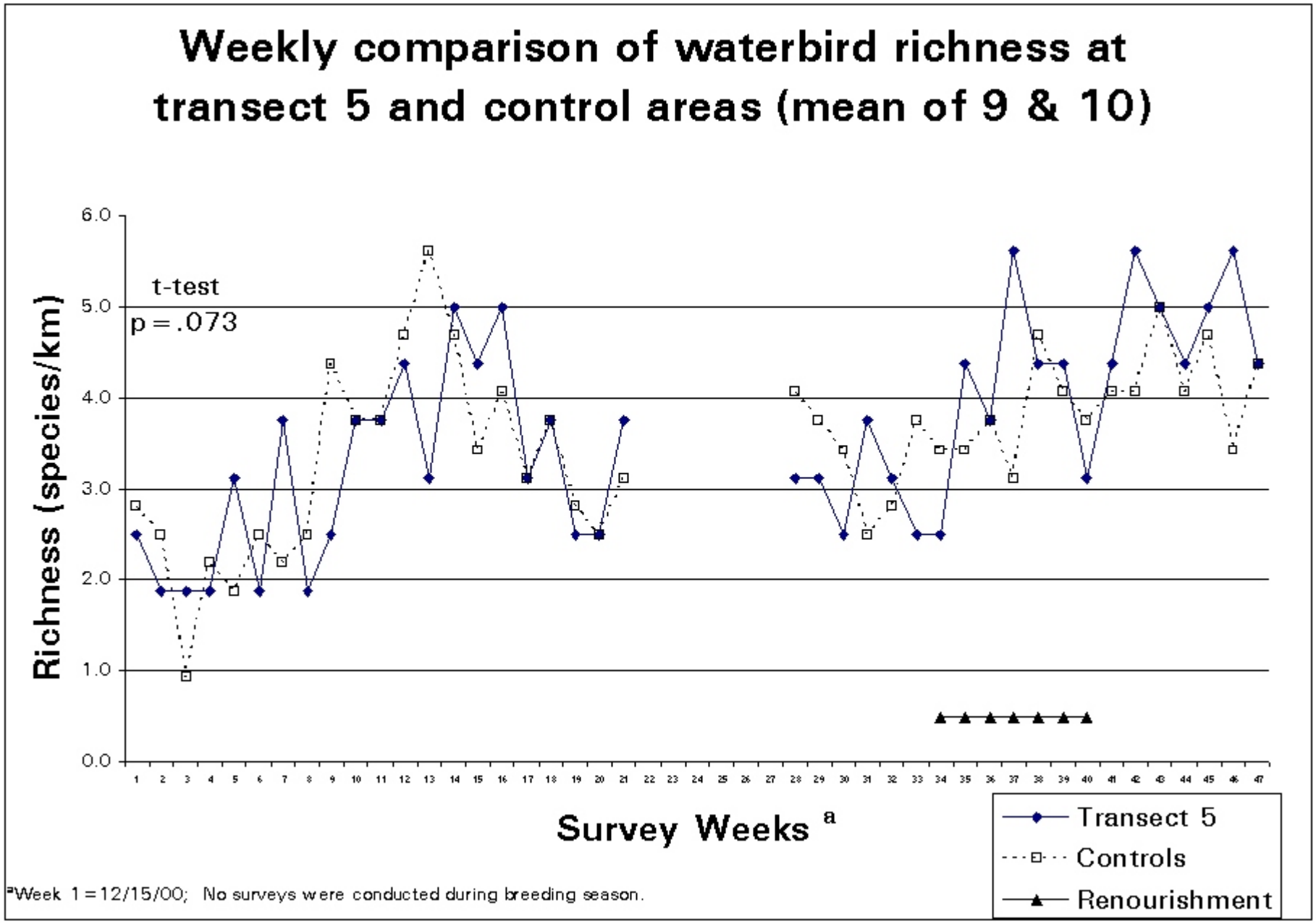
Weekly comparison of waterbird richness at transect 2 and control areas (mean of 9 & 10)

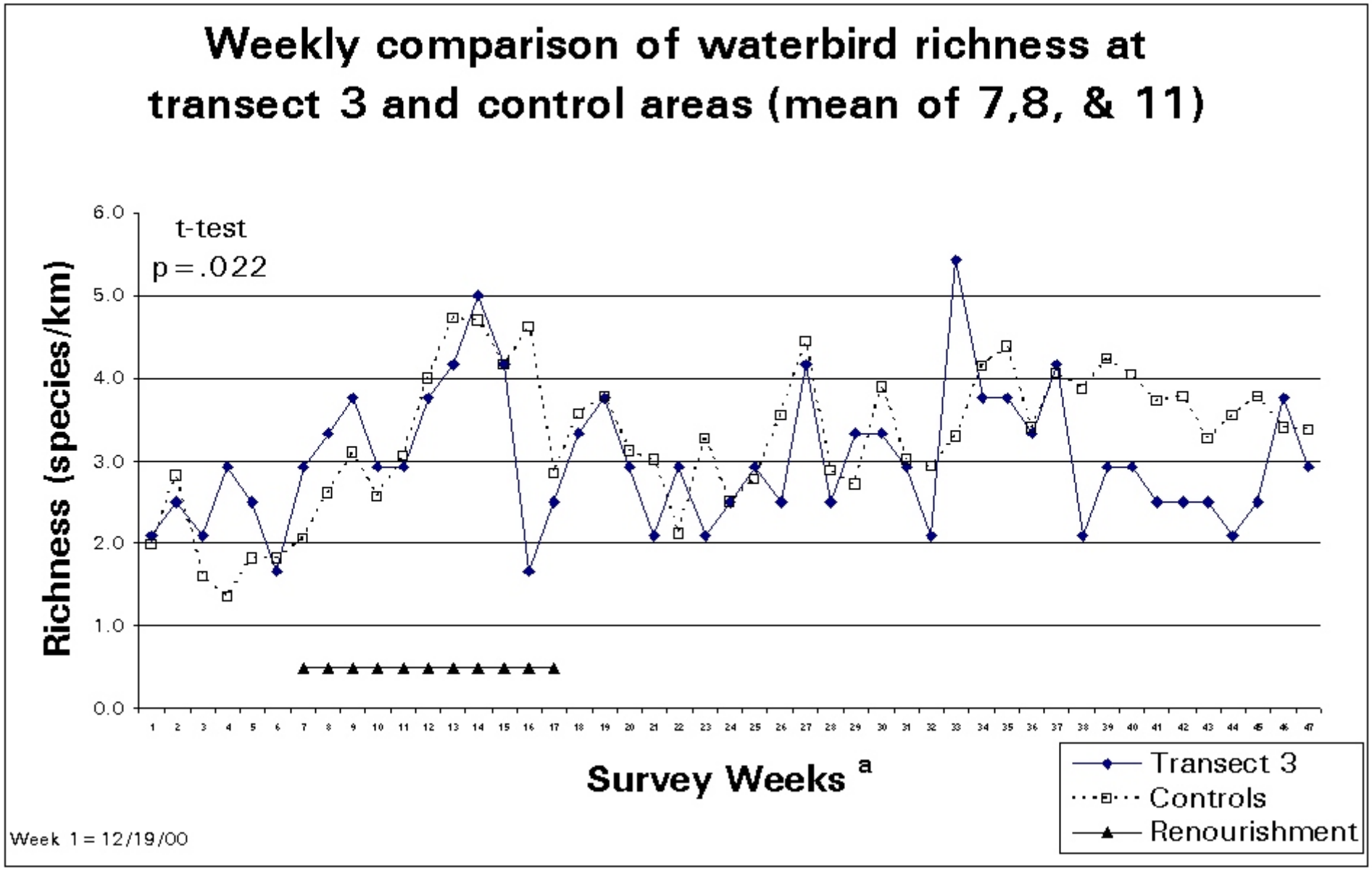


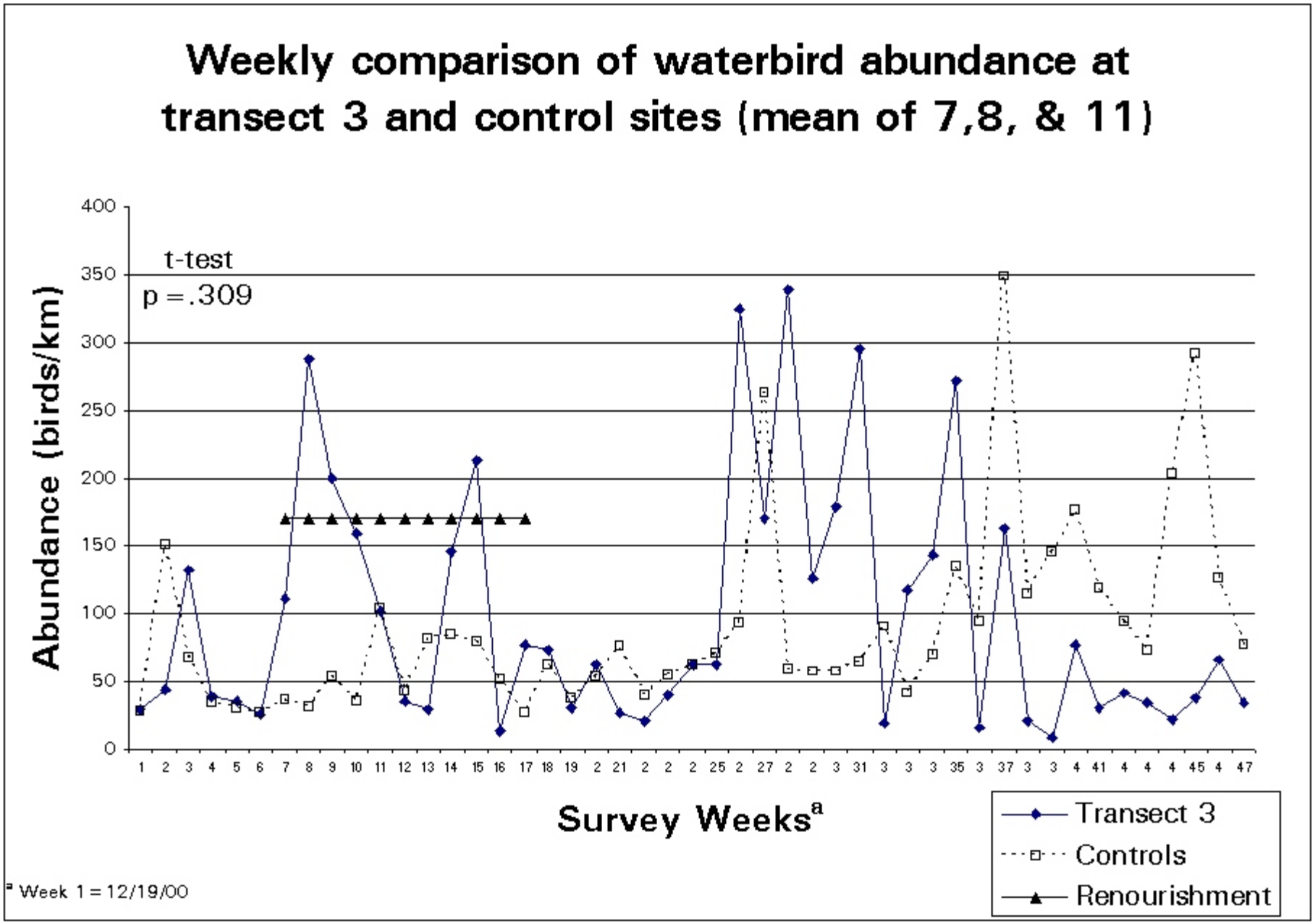
[a]Week 1 = 12/19/00; No surveys were conducted during breeding season.


Weekly comparison of waterbird abundance at transect 2 and control sites (mean of 9 & 10)
Abundance (birds/km)
500
450
400
350
300
250
200
150
100
50
0
t-test
p = .104
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Survey Weeks [a]
transect 2
control
Renourishment
[a]Week 1 = 12/19/00; No surveys were conducted during breeding


Weekly comparison of waterbird abundance at transect 5 and control sites (mean of 9 & 10)
Abundance (birds/km)
1200
1000
800
600
400
200
0
t-test
p = .279
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Survey Weeks a
transect 5
control
Renourishment
aWeek 1 = 12/15/00; No surveys were conducted during breeding season.


Weekly comparison of waterbird richness at transect 5 and control areas (mean of 9 & 10)
Richness (species/km)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
t-test
p = .073
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Survey Weeks [a]
Transect 5
Controls
Renourishment
[a]Week 1 = 12/15/00; No surveys were conducted during breeding season.

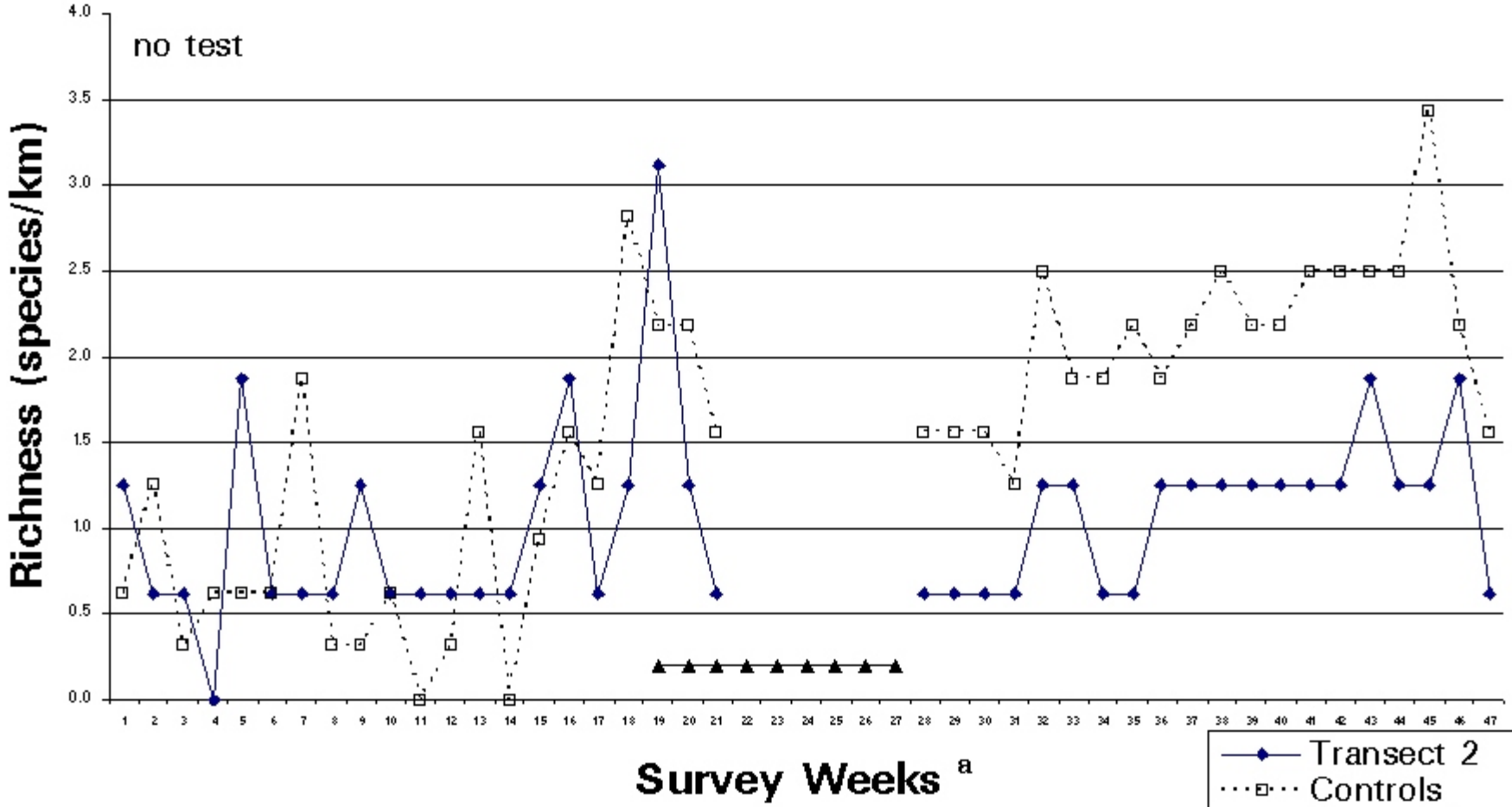

Weekly comparison of waterbird richness at transect 3 and control areas (mean of 7,8, & 11)
t-test
p = .022
Richness (species/km)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Survey Weeks a
Transect 3
Controls
Renourishment
Week 1 = 12/19/00


Weekly comparison of waterbird abundance at transect 3 and control sites (mean of 7,8, & 11)
t-test
p = .309
Abundance (birds/km)
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 2 21 2 2 2 25 2 27 2 2 3 31 3 3 3 35 3 37 3 3 4 41 4 4 4 45 4 47
Survey Weeks[a]
Transect 3
Controls
Renourishment
[a] Week 1 = 12/19/00

APPENDIX J

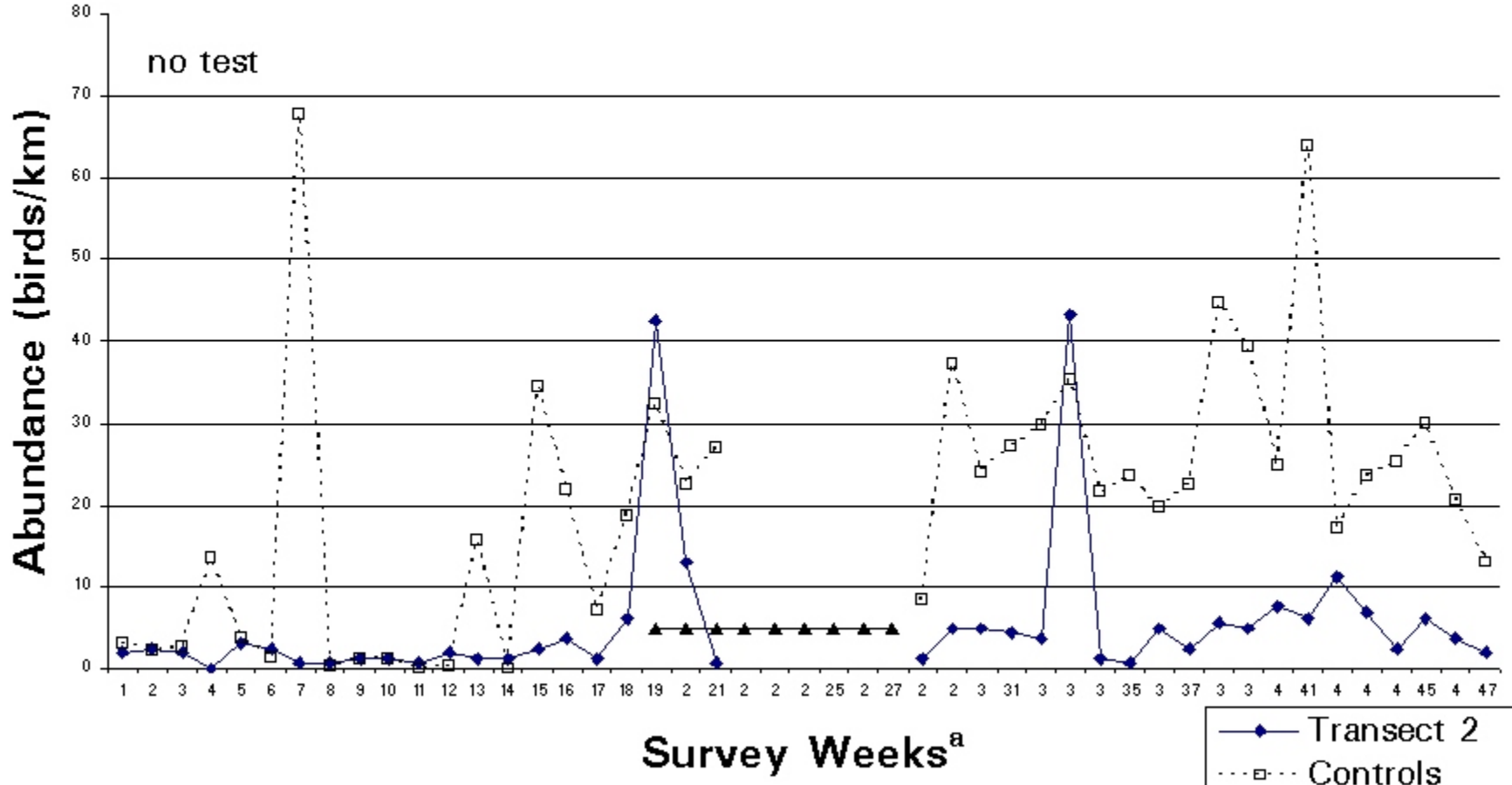
FIGURES DEPICTING WEEKLY SHOREBIRD RICHNESS AND ABUNDANCE AT RENOURISHED TRANSECTS AND CONTROL AREAS

Weekly comparison of shorebird richness at transect 2 and control areas (mean of 9 & 10)

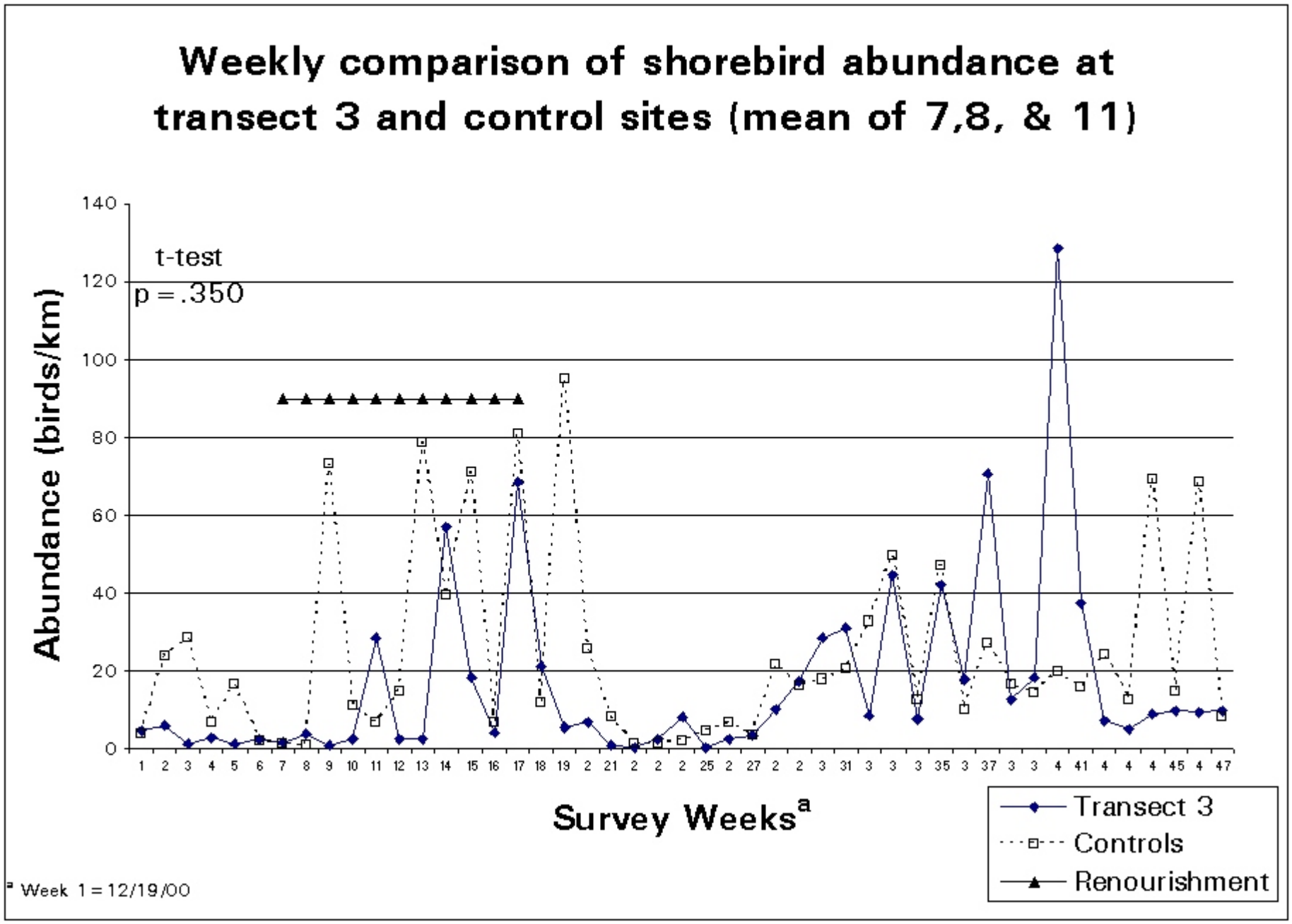


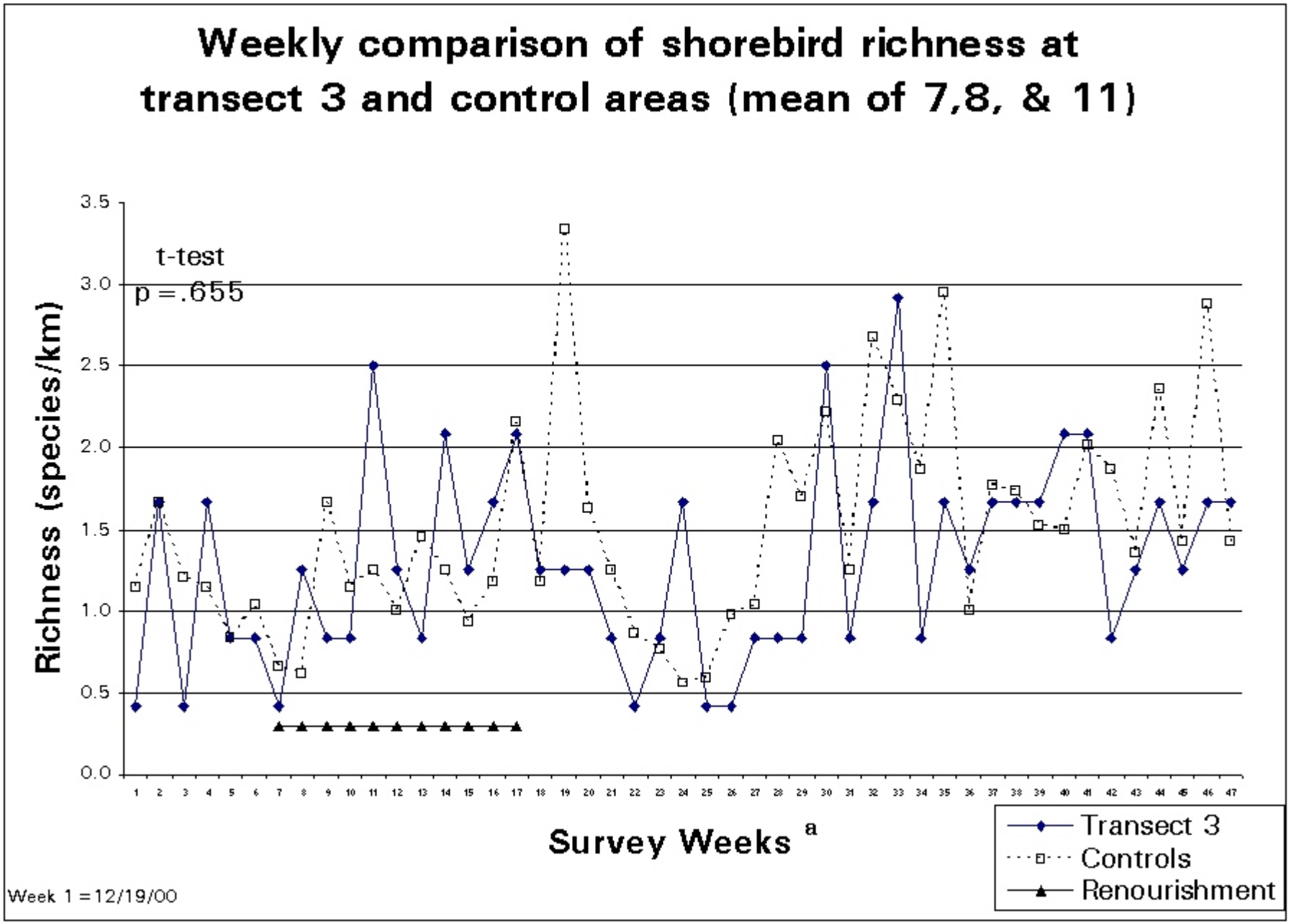
Week 1 = 12/19/00; No surveys were conducted during breeding season.

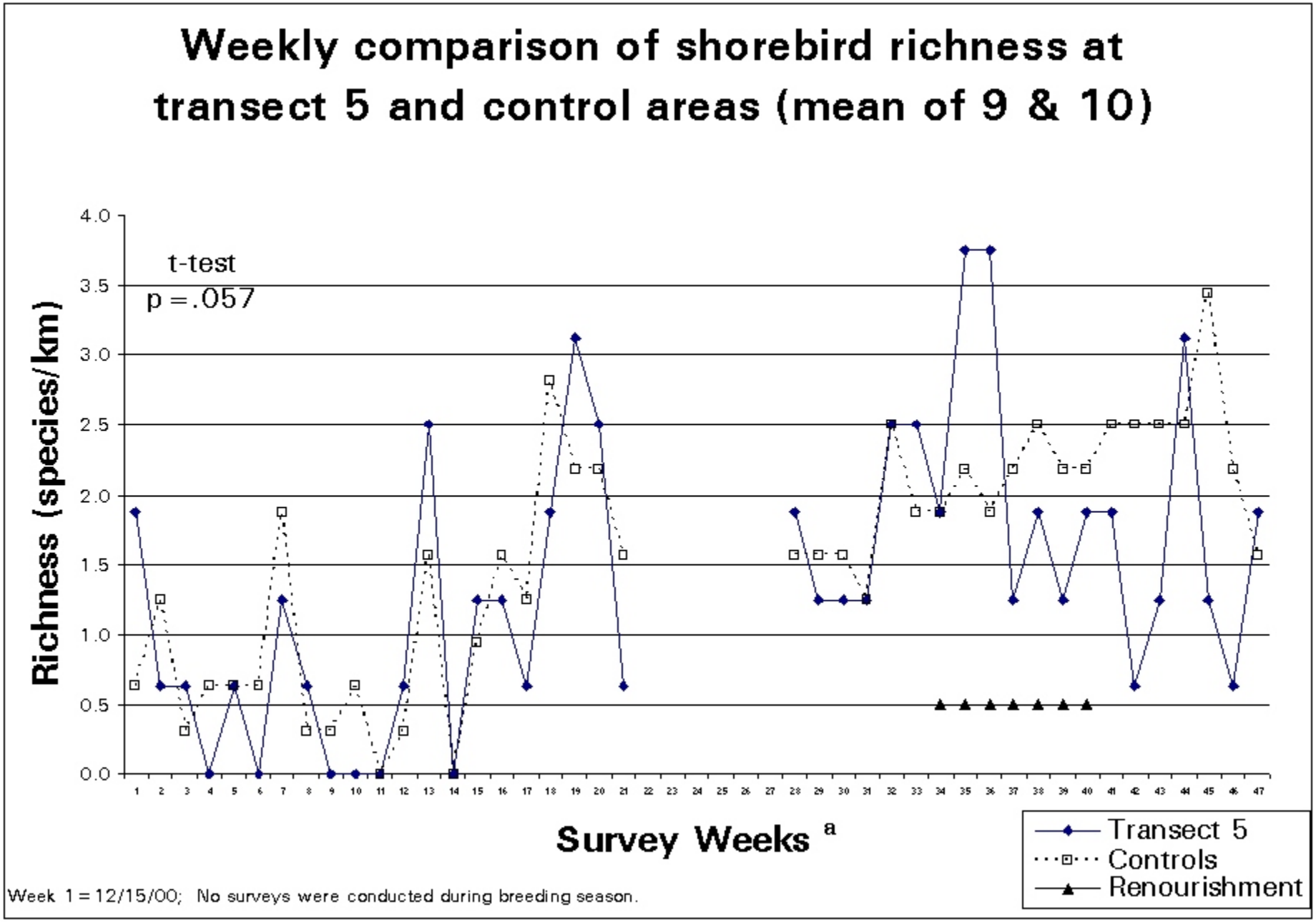
Weekly comparison of shorebird abundance at transect 2 and control sites (mean of 9 & 10)



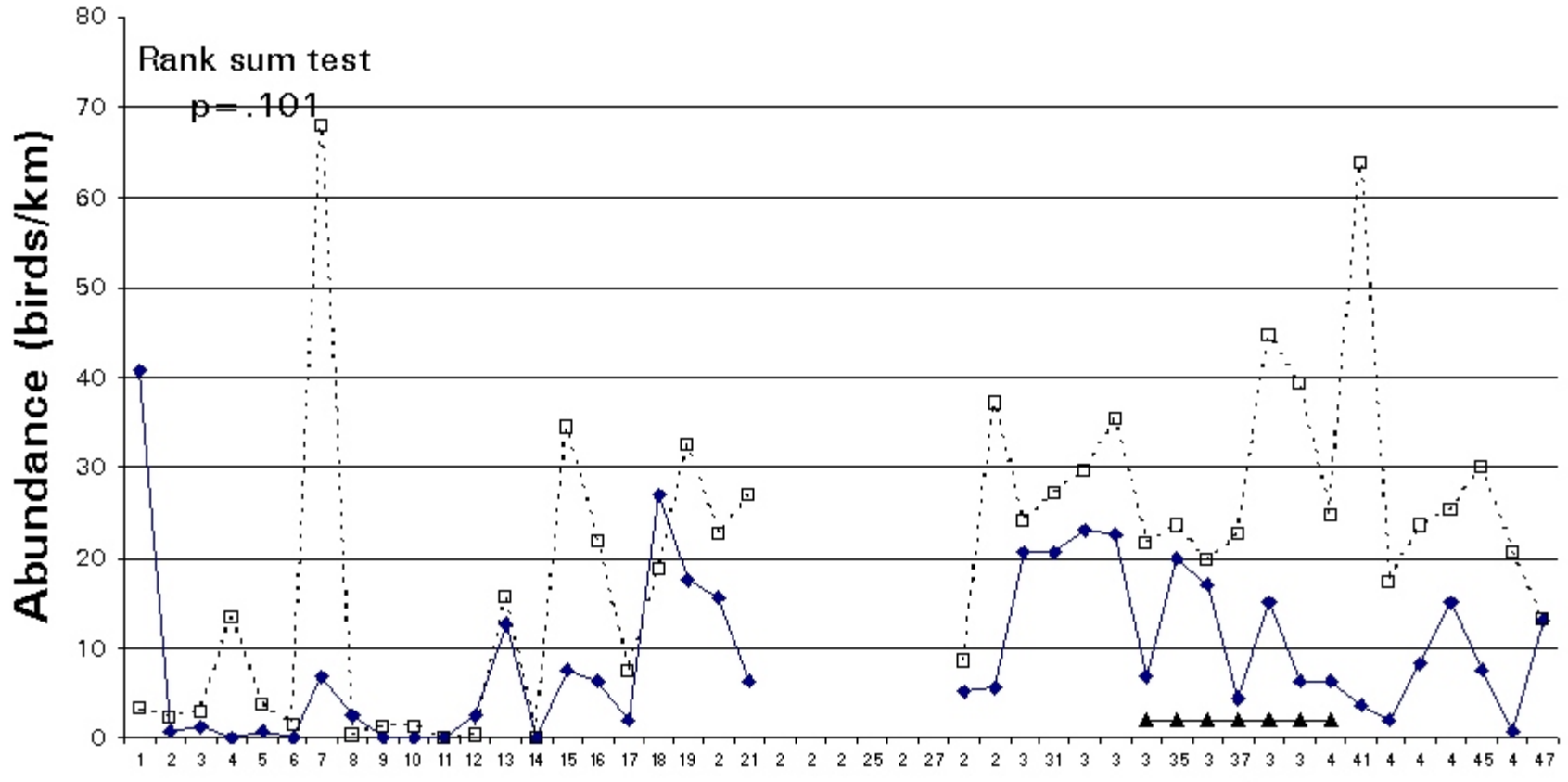
[a] Week 1 = 12/19/00; No surveys were conducted during breeding season.


Weekly comparison of shorebird abundance at transect 3 and control sites (mean of 7,8, & 11)
Abundance (birds/km)
140
120
100
80
60
40
20
0
t-test
p = .350
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 2 21 2 2 2 25 2 27 2 2 3 31 3 3 3 35 3 37 3 3 4 41 4 4 4 45 4 47
Survey Weeks[a]
Transect 3
Controls
Renourishment
[a] Week 1 = 12/19/00


Weekly comparison of shorebird richness at transect 3 and control areas (mean of 7,8, & 11)
t-test
p = .655
Richness (species/km)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Survey Weeks a
Transect 3
Controls
Renourishment
Week 1 = 12/19/00


Weekly comparison of shorebird richness at transect 5 and control areas (mean of 9 & 10)
t-test
p = .057
Richness (species/km)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Survey Weeks a
Transect 5
Controls
Renourishment
Week 1 = 12/15/00; No surveys were conducted during breeding season.

Weekly comparison of shorebird abundance at transect 5 and control sites (mean of 9 & 10)



[a] Week 1 = 12/15/00; No surveys were conducted during breeding season.